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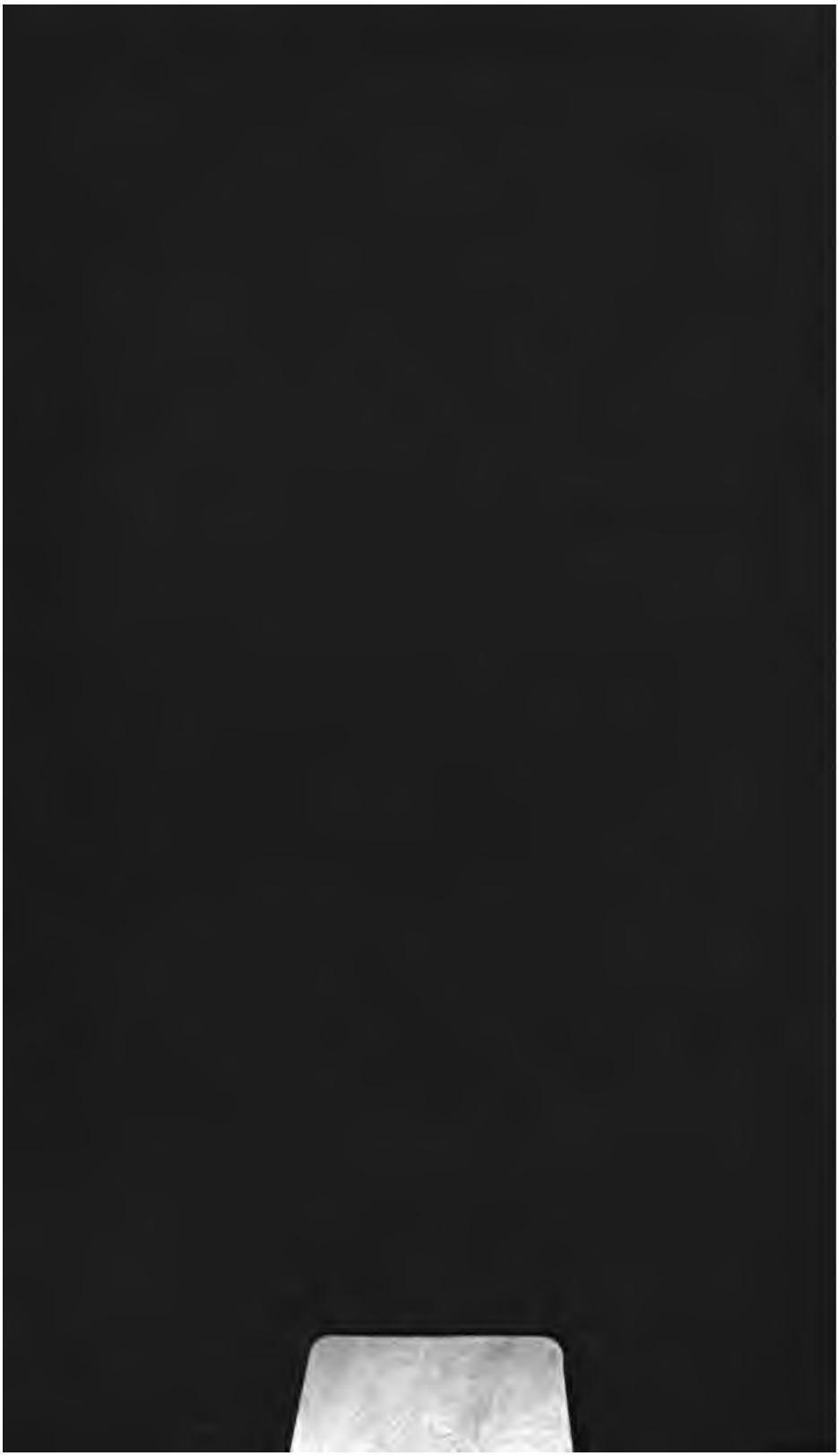

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PART I.

CONTAINING

THE DESCRIPTIVE ANATOMY OF THE BONES, JOINTS, AND MUSCLES, AND A PORTION OF THE GENERAL ANATOMY

ILLUSTRATED BY 241 ENGRAVINGS ON WOOD.

LONDON:
WALTON AND MABERLY,
UPPER GOWER STREET, AND IVY LANE, PATERNOSTER ROW.
1864.

165. e. 4.

LONDON:
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A NEW Edition of "Quain's Anatomy" having been required, the duty of editing the Descriptive Anatomy has been undertaken by Dr. Allen Thomson, Professor of Anatomy in the University of Glasgow, and by Dr. Cleland, Professor of Anatomy in Queen's College, Galway. The text of the part now published has been thoroughly revised, and in a great measure recast, by Dr. Cleland, with the assistance and supervision of Dr. Thomson. New Figures have for the most part been substituted for those of the former editions, drawn on a larger scale, and it is hoped more illustrative of the objects. The duty of selecting these figures and superintending their execution has been performed by Dr. Thomson. All those of the Bones and most of those of the Joints have been drawn by the Artist from the natural objects. Many of the figures of the Muscles have also been drawn from nature, and most of the others, though founded upon the most approved published prints, have been modified and finished from actual dissections. The plan of inscribing the names of the parts on the figures was, after careful consideration, not adopted, since its advantage over descriptions in close proximity, by reference letters or numbers, was thought to be on the whole more specious than real, and it has the disadvantage of disfiguring and obscuring the design.

The General Anatomy is, as before, revised by Dr. Sharpey, and is paged separately.

The present part will be speedily followed by the rest of the work, which, when complete, will form two volumes.

ELEMENTS OF ANATOMY.

INTRODUCTION.

Division of natural Bodies.—The material objects which exist in nature belong to two great divisions; those which are living or which have lived, and those which neither are nor have ever been endowed with life. The first division comprehends animals and plants, the other mineral substances.

ERRATA.

DESCRIPTIVE ANATOMY.

Page 13, line 17 from the bottom, the words "posterior" and "anterior" should be transposed.

Page 225, Figure 185, the number 14 marked as pointing to the median nerve is misplaced. It should be between 11 and 15.

inorganic.

Object of Anatomy.—The object of anatomy, in its most extended sense, is to ascertain and make known the structure of organised bodies. But the science is divided according to its subjects; the investigation of the structure of plants forms a distinct study under the name of Vegetable Anatomy, and the anatomy of the lower animals is distinguished from that of man or human anatomy under the name of Comparative Anatomy.

Organs and Textures.—On examining the structure of an organised body, we find that it is made up of members or organs, through means of which its functions are executed, such as the root, stem, and leaves of a plant, and the heart, brain, stomach, and limbs of an animal; and further, that these organs are themselves made up of certain constituent materials named tissues or textures, as the cellular, woody, and vascular tissues of the vegetable, or the osseous, muscular, connective, vascular, and various others, which form the animal organs.

Most of the textures occur in more than one organ, and some of them indeed, as the connective and vascular, in nearly all, so that a multitude of organs, and these greatly diversified, are constructed out of a small number of constituent tissues, just as many different words are formed by the varied combinations of a few letters; and parts of the body, differing widely in form, construction, and uses, may agree in the nature of their component materials. Again, as the same texture possesses the same essential characters in whatever organ or region it is found, it is obvious that the structure and properties of each tissue may be made the subject of investigation apart from the organs into whose formation it enters.

General and Descriptive Anatomy.—These considerations naturally point out to the Anatomist a twofold line of study, and have led to the subdivision of Anatomy into two branches, the one of which treats of the nature and general properties of the component textures of the body: the other treats of its several organs, members, and regions, describing the outward form and internal structure of the parts, their relative situation and mutual connection, and the successive conditions which they present in the progress of their formation or development. The former is usually named "General" Anatomy, or "Histology;" * the latter "Descriptive" Anatomy.

* From *ἱστὸς*, a web.

GENERAL ANATOMY.

GENERAL CONSIDERATIONS ON THE TEXTURES.

Enumeration of the Textures.—The human body consists of solids and fluids. Only the solid parts can be reckoned as textures, properly so called; still, as some of the fluids, viz. the blood, chyle, and lymph, contain in suspension solid organised corpuscles of determinate form and organic properties, and are not mere products or secretions of a particular organ, or confined to a particular part, the corpuscles of these fluids, though not coherent textures, are to be looked upon as organised constituents of the body, and as such may not improperly be considered along with the solid tissues. In conformity with this view the textures and other organised constituents of the frame may be enumerated as follows :—

The blood, chyle, and lymph.
Epidermic tissue, including epithelium, cuticle, nails, and hairs.
Pigment.
Adipose tissue.
Connective tissue, viz.
- Areolar tissue.
- Fibrous tissue.
- Elastic tissue.

Cartilage and its varieties.
Bone or osseous tissue.
Muscle.
Nerve.
Blood-vessels.
Absorbent vessels and glands.
Serous and synovial membranes.
Mucous membrane.
Skin.
Secreting glands.
Vascular or ductless glands.

Organic Systems.—Every texture taken as a whole was viewed by Bichat as constituting a peculiar system, presenting throughout its whole extent in the body characters either the same, or modified only so far as its local connections and uses render necessary; he accordingly used the term

"organic systems" to designate the textures taken in this point of view, and the term has been very generally employed by succeeding writers. Of the tissues or organic systems enumerated, some are found in nearly every organ; such is the case with the connective tissue, which serves as a binding material to hold together the other tissues which go to form an organ; the vessels, which convey fluids for the nutrition of the other textures, and the nerves, which establish a mutual dependence among different organs, imparting to them sensibility, and governing their movements. These were named by Bichat the "general systems." Others again, as the cartilaginous and osseous, being confined to a limited number or to a particular class of organs, he named "particular systems." Lastly, there are some tissues of such limited occurrence that it has appeared more convenient to leave them out of the general enumeration altogether, and to defer the consideration of them until the particular organs in which they are found come to be treated of. Accordingly, the tissues peculiar to the crystalline lens, the teeth, and some other parts, though equally independent textures with those above enumerated, are for the reason assigned not to be described in this part of the work.

Structural Elements.—It is further to be observed, that the tissues above enumerated are by no means to be regarded as simple structural elements; on the contrary, many of them are complex in constitution, being made up of several more simple tissues. The blood-vessels, for instance, are composed of several coats of different structure, and some of these coats consist of more than one tissue. They are properly rather organs than textures, although they are here included with the latter in order that their general structure and properties may be considered apart from their local distribution; but indeed it may be remarked, that the distinction between textures and organs has not in general been strictly attended to by anatomists. The same remark applies to mucous membrane and the tissue of the glands, which structures, as commonly understood, are highly complex. Were we to separate every tissue into the simplest parts which possessed assignable form, we should resolve the whole into a very few constructive elements; and, having regard to form merely, and not to difference of chemical constitution, we might reduce these elements to the following, viz.—1. *simple fibre;* 2. *homogeneous membrane,* either spread out or forming the walls of tubes or cells; and 3. *globules* or *granules,* varying in diameter from the $\frac{1}{12000}$th to the $\frac{1}{6000}$th of an inch. These, with a quantity of *amorphous matter,* homogeneous or molecular, might be said, by their varied combinations, to make up the different kinds of structure which we recognise in the tissues; and if we take into account that the chemical nature of these formative elements and of the amorphous matter may vary, it will be readily conceived that extremely diversified combinations may be produced.

PHYSICAL PROPERTIES.

The animal tissues like other forms of matter are endowed with various physical properties, such as consistency, density, colour, and the like. Of these the most interesting to the Physiologist is the property of imbibing fluids, and of permitting fluids to pass through their substance, which is essentially connected with some of the most important phenomena that

occur in the living body, and seems indeed to be indispensable for the maintenance and manifestation of life.

All the soft tissues contain water, some of them more than four-fifths of their weight; this they lose by drying, and with it their softness and flexibility, and so shrink up into smaller bulk and become hard, brittle, and transparent; but when the dried tissue is placed in contact with water, it greedily imbibes the fluid again, and recovers its former size, weight, and mechanical properties. The imbibed water is no doubt partly contained mechanically in the interstices of the tissue, and retained there by capillary attraction, like water in moist sandstone or other inorganic porous substances; but the essential part of the process of imbibition by an animal tissue is not to be ascribed to mere porosity, for the fluid is not merely lodged between the fibres or laminæ, or in the cavities of the texture; a part, probably the chief part, is incorporated with the matter which forms the tissue, and is in a state of union with it, more intimate than could well be ascribed to the mere inclusion of a fluid in the pores of another substance. Be this as it may, it is clear that the tissues, even in their inmost substance, are permeable to fluids, and this property is indeed necessary, not only to maintain their due softness, pliancy, elasticity, and other mechanical qualities, but also to allow matters to be conveyed into and out of their substance in the process of nutrition.

CHEMICAL COMPOSITION.

Ultimate Constituents.—The human body is capable of being resolved by ultimate analysis into chemical elements, or simple constituents, not differing in nature from those which compose mineral substances. Of the chemical elements known to exist in nature, the following have been discovered in the human body, though it must be remarked, that some of them occur only in exceedingly minute quantity, if indeed they are constant: oxygen, hydrogen, carbon, nitrogen, phosphorus, sulphur, chlorine, fluorine, potassium, sodium, calcium, magnesium, iron, silicon, manganese, aluminium, copper.

Proximate Constituents.—The ultimate elements do not directly form the textures or fluids of the body; they first combine to form certain compounds, and these appear as the more immediate constituents of the animal substance; at least the animal tissue or fluid yields these compounds, and they in their turn are decomposed into the ultimate elements. Of the immediate constituents some are found also in the mineral kingdom, as for example, water, chloride of sodium or common salt, and carbonate of lime; others, such as albumen, fibrin, and fat, are peculiar to organic bodies, and are accordingly named the proximate organic principles.

The animal proximate principles have the following leading characters: They all contain carbon, oxygen, and hydrogen, and the greater number also nitrogen; they are all decomposed by a red heat; and excepting the fatty and acid principles, they are, for the most part, extremely prone to putrefaction, or spontaneous decomposition, at least, when in a moist state; the chief products to which their putrefaction gives rise being water, carbonic acid, ammonia, and sulphuretted, phosphuretted, and carburetted hydrogen gases. The immediate compounds found in the solids and fluids of the human body are the following:

I. *Azotised Substances*, or such as contain nitrogen, viz., albumen, blood-fibrin, muscle-fibrin (or syntonin), casein, globulin, gelatin, chondrin, extractive soluble in alcohol, extractive soluble in water, salivin, kreatin, kreatinine, pepsin, mucus, horny matter or keratin, pigment, hæmatin, pyin,

urea, uric acid, hippuric acid, inosinic acid, sarkin (or hypoxanthin), leucin, tyrosin, azotised biliary compounds.

II. *Substances destitute of Nitrogen*, viz., fatty matters (except cerebric acid), glycogen (or animal starch), animal glucose, sugar of milk, inosit, lactic, formic, and oxalic acids, certain principles of the bile.

Some of the substances now enumerated require no further notice in a work devoted to anatomy. Of the rest, the greater number will be explained, as far as may be necessary for our purpose, in treating of the particular solids or fluids in which they are chiefly found; but there are a few of more general occurrence, the leading characters of which it will be advisable here to state very briefly, viz.:—

A. *Albuminoid Principles*, albumen, fibrin, and casein. Coagulable—fibrin spontaneously, albumen by heat, casein by rennet. Precipitated by mineral acids, tannic acid, alcohol, corrosive sublimate, subacetate of lead, and several other metallic salts. *When coagulated*, not soluble in water, cold or hot, unless after being altered by long boiling; insoluble in alcohol; soluble in alkalies; soluble in very dilute and also in concentrated acids; the solutions precipitated by red and yellow prussiates of potash.

B. *Gelatinous Principles*, gelatin and chondrin. Not dissolved by cold water; easily soluble in hot water; the solution (at least that of gelatin) congealing when cold. Precipitated by tannic acid, alcohol, ether, and corrosive sublimate, and not by the prussiates of potash. *Chondrin* precipitated by acids, alum, sulphate of alumina, persulphate of iron, and acetate of lead, which do not precipitate gelatin.

C. *Extractive Matters*, associated with lactic acid and lactates. All soluble in water, both cold and hot; some in water only; some in water and rectified spirit; some in water, rectified spirit, and pure alcohol.

D. *Fatty Matters*. Not soluble in water, cold or hot; soluble in ether and in hot alcohol.

It has been shown by Mr. Graham,* that chemical substances may be distinguished into two classes—the *crystalloid* and the *colloid*—which differ in several important characters. Crystalloid bodies, of which water, most salts and acids, and sugar, may be taken as examples, have a disposition to assume a crystalline state; their solutions are usually sapid, diffluent, and free from viscosity; they readily diffuse in liquids, and pass through moist organic membranes or artificial septa of organic matter, such as parchment-paper. Colloids, on the other hand, are characterised by low diffusibility and great indisposition to permeate organic septa, so that when they are associated with crystalloids, the latter may be easily separated by diffusion through a septum into another fluid; *i.e.* by "dialysis." Colloids are, moreover, generally tasteless; they have little or no tendency to crystallize, and their solution, when concentrated, is always, in a certain degree, viscous or gummy. Among the colloids may be reckoned hydrated silicic acid, and various hydrated metallic peroxides, also albumen, fibrin, gelatin, starch, gum, and vegetable and animal extractive matters. Several substances may exist either in the colloid or the crystalloid condition. In point of *chemical* activity the crystalloid appears to be the more energetic, and the colloidal the more inert form of matter; but the colloids possess an activity of their own, arising out of their physical properties, and especially their penetrability, by which they become a medium for liquid diffusion, like water itself. Another characteristic is their tendency to change; the solution of hydrated silicic acid, for instance, cannot be preserved; after a time it congeals. In this respect a liquid colloid might be compared to liquid water at a temperature below freezing, or to a supersaturated saline solution. This dominant tendency of the particles of a colloid to cohere, aggregate, and contract, is obvious in the gradual

* Liquid Diffusion applied to Analysis,—Phil. Trans., 1861.

thickening of the liquid and its conversion into a jelly; and in the jelly itself the contraction still proceeds, causing separation of water, and division into a clot and serum. Their permeability to fluids, their ready capability of physical changes, and their comparative chemical inertness, are properties by which colloid bodies seem fitted to form organised structures, and to take part in the processes of the living economy. In a recent research,* Mr. Graham has found that silicic acid may combine both in a dissolved and in a gelatinous state with a variety of very different fluids without undergoing alteration; and presuming that the organic colloids are invested with similar wide powers of combination, he remarks that the capacity of a mass of gelatinous silicic acid to assume alcohol, or even olein, without disintegration or alteration of form, and to yield it up again in favour of some other substituted fluid, may perhaps afford a clue to the penetration of the colloid matter of animal membrane by fatty and other bodies insoluble in water; and moreover, that the existence of *fluid* compounds of silicic acid of a like nature, suggests the possibility of the formation of a compound of colloid albumen with olein, soluble also and capable of circulating with the blood.

The important relation which this new chemical doctrine bears to the constitution and organic processes of the animal body, has appeared to justify the introduction of the present notice of it; for further information the reader is referred to the sources already cited.

VITAL PROPERTIES OF THE TEXTURES.

Of the phenomena exhibited by living bodies, there are many which, in the present state of knowledge, cannot be referred to the operation of any of the forces which manifest themselves in inorganic nature; they are therefore ascribed to certain powers, endowments, or properties, which so far as known, are peculiar to living bodies, and are accordingly named "vital properties." These vital properties are called into play by various stimuli, external and internal, physical, chemical, and mental; and the assemblage of actions thence resulting has been designated by the term "life." The words "life" and "vitality" are often also employed to signify a single principle, force, or agent, which has been regarded as the common source of all vital properties, and the common cause of all vital actions.

As ordinary physical forces, such as mechanical motion, heat, electricity, chemical action, and the like, although differing from each other in specific character and mode of operation, are nevertheless shown to be mutually convertible and equivalent, and are held to be but different modifications of one and the same common force or energy, so it may in like manner come to be shown that vital action is similarly related to the physical forces as they are related to each other, and is also a manifestation, under conditions special to the living economy, of the same common energy.

1. *Assimilative Force.*—Of the vital properties, there is one which is universal in its existence among organised beings, namely, the property, with which all such beings are endowed, of converting into their own substance, or "assimilating," alimentary matter. The operation of this power is seen in the continual renovation of the materials of the body by nutrition, and in the increase and extension of the organised substance, which necessarily takes place in growth and reproduction; it manifests itself, moreover, in individual textures as well as in the entire organism. It has been called the "assimilative force or property," "organising force,"

* On the Properties of Silicic Acid and other Analogous Colloidal Substances,—Proceedings of the Royal Society, June 16th, 1864.

"plastic force," and is known also by various other names. But in reality the process of assimilation produces two different effects on the matter assimilated: first, the nutrient material, previously in a liquid or amorphous condition, acquires determinate form; and secondly, it may, and commonly does, undergo more or less change in its chemical qualities. Such being the case, it seems reasonable, in the mean time, to refer these two changes to the operation of two distinct agencies, and, with Schwann, to reserve the name of "plastic" force for that which gives to matter a definite organic form; the other, which he proposes to call "metabolic," being already generally named "vital affinity." Respecting the last-named agency, however, it has been long since remarked, that although the products of chemical changes in living bodies for the most part differ from those appearing in the inorganic world, the difference is nevertheless to be ascribed, not to a peculiar or exclusively vital affinity different from ordinary chemical affinity, but to common chemical affinity operating in circumstances or conditions which present themselves in living bodies only.

2. *Vital Contractility.*—When a muscle, or a tissue containing muscular fibres, is exposed in an animal during life, or soon after death, and scratched with the point of a knife, it contracts or shortens itself; and the property of thus visibly contracting on the application of a stimulus is named "vital contractility," or "irritability," in the restricted sense of this latter term. The property in question may be called into play by various other stimuli besides that of mechanical irritation—especially by electricity, the sudden application of heat or cold, salt, and various other chemical agents of an acrid character, and, in a large class of muscles, by the exercise of the will, or by involuntary mental stimuli.

The evidence that a tissue possesses vital contractility is derived, of course, from the fact of its contracting on the application of a stimulus. Mechanical irritation, as scratching with a sharp point, or slightly pinching with the forceps, electricity obtained from a piece of copper and a piece of zinc, or from a larger apparatus if necessary, and the sudden application of cold, are the stimuli most commonly applied. Heat, when of certain intensity, is apt to cause permanent shrinking of the tissue, or "crispation," as it has been called, which, though quite different in nature from vital contraction, might yet be mistaken for it; and the same may happen with acids and some other chemical agents, when employed in a concentrated state; in using such stimulants, therefore, care should be taken to avoid this source of deception.

3. *Vis Nervosa.*—The stimulus which excites contraction may be applied either directly to the muscle, or to the nerves entering it, which then communicate the effect to the muscular fibre, and it is in the latter mode that the voluntary or other mental stimuli are transmitted to muscles from the brain. Moreover, a muscle may be excited to contract by irritation of a nerve not directly connected with it. The stimulus, in this case, is first conducted by the nerve irritated, to the brain or spinal cord; it is then, without participation of the will, and even without consciousness, transferred to another nerve, by which it is conveyed to the muscle, and thus at length excites muscular contraction. The property of nerves by which they convey stimuli to muscles, whether directly, as in the case of muscular nerves, or circuitously, as in the case last instanced, is named the "vis nervosa."

4. *Sensibility.*—We become conscious of impressions made on various parts of the body, both external and internal, by the faculty of sensation;

and the parts or textures, impressions on which are felt, are said to be sensible, or to possess the vital property of "sensibility."

This property manifests itself in very different degrees in different parts; from the hairs and nails, which indeed are absolutely insensible, to the skin of the points of the fingers, the exquisite sensibility of which is well known. But sensibility is a property which really depends on the brain and nerves, and the different tissues owe what sensibility they possess to the sentient nerves which are distributed to them. Hence it is lost in parts severed from the body, and it may be immediately extinguished in a part, by dividing or tying the nerves so as to cut off its connection with the brain.

It thus appears that the nerves serve to conduct impressions to the brain, which give rise to sensation, and also to convey stimuli to the muscles, which excite motion; and it is not improbable that, in both these cases, the conductive property exercised by the nervous cords may be the same, the difference of effect depending on this, that in the one case the impression is carried upwards to the sensorial part of the brain, and in the other downwards to an irritable tissue, which it causes to contract; the stimulus in the latter case either having originated in the brain, as in the instance of voluntary motion, or having been first conducted upwards, by an afferent nerve, to the part of the cerebro-spinal centre devoted to excitation, and then transferred to an efferent or muscular nerve, along which it travels to the muscle. If this view be correct, the power by which the nerves conduct sensorial impressions and the before-mentioned "vis nervosa" are one and the same vital property; the difference of the effects resulting from its exercise, and, consequently, the difference in function of sensorial and motorial nerves, being due partly to the different nature of the stimuli applied, but especially to a difference in the susceptibility and mode of reaction of the organs to which the stimuli are conveyed.

DEVELOPMENT OF THE TEXTURES.

The tissues of organised bodies, however diversified they may ultimately become, show a wonderful uniformity in their primordial condition. From researches which have been made with the microscope, especially during the last few years, it has been ascertained that the different organised structures found in plants, and to a certain extent, also those of animals, originate by means of minute corpuscles, which, having for the most part a vesicular structure, have been named cells. These so-called cells, remaining as separate corpuscles in the fluids, and grouped together in the solids, persisting in some cases with but little change, in others undergoing a partial or thorough transformation, produce the varieties of form and structure met with in the animal and vegetable textures. Nay, the germ from which an animal originally springs, so far at least as it has been recognised under a distinct form, appears as a cell; and the embryo, in its earliest stages, is but a cluster of cells produced apparently from that primordial one; no distinction of texture being seen till the process of transformation of the cells has begun.

No branch of knowledge can be said to be complete; but, even now that a quarter of a century has elapsed since the promulgation of the cell-doctrine, there is, perhaps, none which can be more justly regarded as in a state of progress than that which relates to the origin and development of the textures, and much of the current opinion on the subject is uncertain, and must be received with caution. In these circumstances, in order both to facilitate the exposition, and to explain to the reader more fully the groundwork of the doctrines in question, we shall begin with a short

account of the development of the tissues of vegetables; for it was in consequence of the discoveries made in the vegetable kingdom that the happy idea arose of applying the principle of cell-development to explain the formation of animal structures, and they still afford important aid in the study of that, as yet, more obscure process.

OUTLINE OF THE FORMATION OF VEGETABLE STRUCTURE.

When a thin slice from the succulent part of a plant is viewed under the microscope, it is seen to consist chiefly or entirely of a multitude of vesicles adhering together, of a rounded or angular form, and containing various coloured or colourless matters in their interior; these are the elementary cells (fig. I.; fig. II.,[1 2]). These cells are so constructed that their walls are in close apposition, or are separated only by an intercellular substance, which, according to Hugo von Mohl,* has so great a similarity to the substance of the cell-walls that it is often impossible, even with the aid of chemical re-agents, to discover a line of demarcation between them. That eminent phytologist supposes that within what is commonly called the cell-wall there exists an extremely delicate membrane, constituting an interior vesicle, which he names the "Primordial utricle." This is in most cases so closely applied to the exterior wall as to be undistinguishable; but in young cells, and in those of strictly cellular plants, such as the Algæ, &c., during the whole of their existence it may, according to Mohl, be separated by treating the tissue with alcohol, or hydrochloric or nitric acid, and then the interior vesicle appears shrivelled up and separated from the wall of the cavity. But the reality of the alleged primordial utricle has been called in question, and the supposed internal membrane is held to be merely the limiting surface of the cell-contents shrunk away from the inside of the containing cavity, and perhaps somewhat consolidated and defined by the re-agents employed. Still, whether the cell-contents have a vesicular limiting membrane or not, they originally present a marked contrast in chemical nature to the containing cell-wall and inter-cellular substance, and would appear to fulfil a different purpose in the process of tissue development.†

Fig. I.

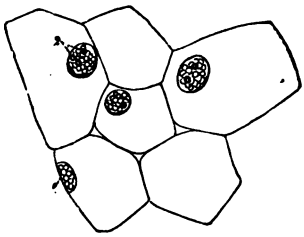


Fig. I.—Nucleated Cells from a Bulbous Root; magnified 290 diameters (Schwann).

Besides such cells, phænogamous or flowering plants contain tubes, vessels, and other forms of tissue (fig. II.,[4 6]); but a great many plants of the class cryptogamia are composed entirely of cells, variously modified, it is true, to suit their several destinations, but fundamentally the same throughout; nay, there are certain very simple modes of vegetable existence, in which a single cell may constitute an entire plant, as in the well-known green powdery crust which coats over the trunks of trees, damp walls, and

* Die vegetabilische Zelle; or English translation by Henfrey.

† See an interesting discussion of this subject by Mr. Huxley in the British and Foreign Medical Review for 1853.

other moist surfaces. In this last case, a simple detached cell exercises the functions of an entire independent organism, imbibing and elaborating extraneous matter, extending itself by the process of growth, and continuing its species by generating other cells of the same kind. Even in the aggregated state in which the cells exist in vegetables of a higher order, each cell still, to a certain extent, exercises its functions as a distinct individual; but it is now subject to conditions arising from its connection with the other parts of the plant to which it belongs, and is made to act in harmony with the other cells with which it is associated, in ministering to the necessities of the greater organism of which they are joint members. These elementary parts are therefore not simply congregated into a mass, but combined to produce a regularly organised structure; just as men in an army are not gathered promiscuously, as in a mere crowd, but are regularly combined for a joint object, and made to work in concert for the attainment of it; living and acting as individuals, but subject to mutual and general control.

Now the varied forms of tissue found in the higher orders of plants do not exist in them from the beginning; they are derived from cells. The embryo plant, like the embryo animal, is in its early stages entirely formed of cells, and these of a very simple and uniform character; and it is by a transformation of some of these cells in the further progress of development that the other tissues, as well as the several varieties of cellular tissue itself, are produced. The principal modes, as far as yet known, in which vegetable cells are changed, are the following.

1. The cells may increase in size; simply, or along with some of the other changes to be immediately described.

2. They alter in shape. Cells have originally a spheroidal or rounded figure; and when in the progress of growth they increase equally, or nearly so, in every direction, and meet with no obstacle, they retain their rounded form. When they meet with other cells extending themselves in like

Fig. II. Fig. III.

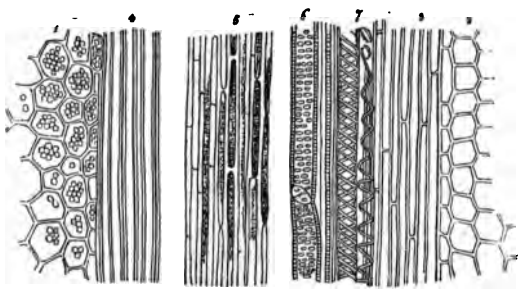


Fig. II.—Textures seen in a Longitudinal Section of the Leaf-Stalk of a Flowering Plant.

Fig. III.—Stellate Vegetable Cells.

manner, they acquire a polyhedral figure (fig. II.,[1 2]), by mutual pressure of their sides. When the growth takes place more in one direction than in another, they become flattened, or they elongate and acquire a prismatic, fusiform, or tubular shape (fig. II.,[3 4 5]). Sometimes, as in the common rush, they assume a starlike figure, by mutual adhesion of their walls at

certain points, whilst they retire from each other elsewhere, so as to leave radiating branches connected with the points of similar rays from adjacent cells (fig. III.).

3. The cells coalesce with adjoining cells, and open into them. In this way a series of elongated cells placed end to end may open into one another by absorption of their cohering membranes, and give rise to a tubular vessel.

4. Changes take place in the substance and in the contents of the cells. These changes may be chemical, as in the conversion of starch into gum, sugar, and jelly, and in the production of various coloured matters, essential oils, and the like. Or they may affect the form and arrangement of the contained substances; thus, the contents of the cell very frequently assume the form of granules, or spherules, of various sizes; at other times the contained matter, suffering at the same time a change in its chemical nature and in consistency, is deposited on the inner surface of the cell-wall, so as to thicken and strengthen it. Such "secondary deposits," as they are termed by botanists, usually occur in successive strata, and the deposition may go on till the cavity of the cell is nearly or completely filled up (fig. IV.). It is in this way that the woody fibre and other hard tissues of the plant are formed. It farther appears that the particles of each layer are disposed in lines, running spirally round the cell. In place of forming a continuous layer, these secondary deposits may leave little spots of the cell-wall uncovered, or less thickly covered, and thus give rise to what is named pitted tissue (fig. II.,[6]); or they may assume the form of a slender fibre or band, single, double, or multiple, running in a spiral manner along the inside of the cavity, or forming a series of separate rings or hoops, as in spiral and annular vessels (fig. II.,[7]). New matter may be absorbed or imbibed into the cells; or a portion of their altered and elaborated contents may escape as a secretion, either by transudation through the cell-wall, or by rupture or absorption of the membrane. Lastly, in certain circumstances, cells may be wholly or partially removed by absorption of their substance.

Fig. IV.

Fig. IV. — Cross Section of Ligneous Cells containing Stratified Deposit.

5. Cells may produce or generate new cells. The mode in which this takes place will be immediately considered, in speaking of the origin of animal cells.

FORMATION OF THE ANIMAL TEXTURES.

Passing now to the development of the animal tissues, it may first be remarked generally, that in some instances the process exhibits an obvious analogy with that which takes place in vegetables; for certain of the animal tissues, in their earlier conditions, appear in form of a congeries of cells, almost entirely resembling the vegetable cells, and, in their subsequent transformations, pass through a series of changes in many respects parallel to some of those which occur in the progress of vegetable development. Cartilage affords a good example of this. Figures V. and VI., A, are magnified representations of cartilage in its early condition; and whoever compares them with the appearance of vegetable cells, shown in figures I. and II., must at once be struck with the resemblance. Fig. VI., B and C, shows the subsequent changes on the primary cells of cartilage; the parietes are seen to have become thickened by deposit of fresh material, and the mass

between the cavities is increased. Now, although in certain cases it would seem that this increase is in part due to deposit of intermediate substance independently of the coalescence of thickened cell-walls, yet the process on the whole may be not unaptly compared with the formation of the hard tissues of plants from the thickened sides of vegetable cells. Again, during the growth of most cartilages the cells increase in number, new ones being formed within the old, as happens in many vegetable structures.

Fig. V.

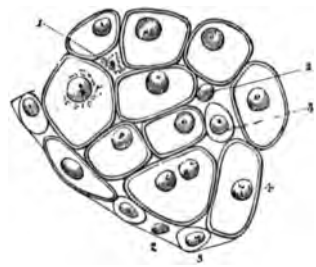
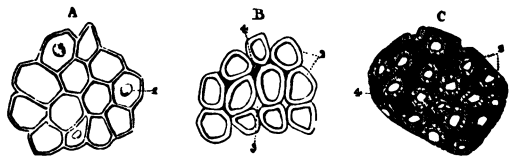


Fig. V.—Section of a Branchial Cartilage of a Tadpole, showing the Early Condition of the Cells; magnified 450 diameters (Schwann).

The instance now given, and others to the same effect, which will be mentioned as we proceed, tend to show a certain fundamental resemblance in the process of textural development in the two kingdoms; but, when we come to inquire into the various modifications which that process exhibits in the formation of particular textures, we encounter serious difficulties. The phenomena are sometimes difficult to observe, and, when recognised, are perhaps susceptible of more than one interpretation; hence have arisen con-

Fig. VI. — Cartilage of the Branchial Ray of a Fish (*Cyprinus erythrophthalmus*) in different Stages of Advancement; magnified 450 diameters (Schwann).

Fig. VI.

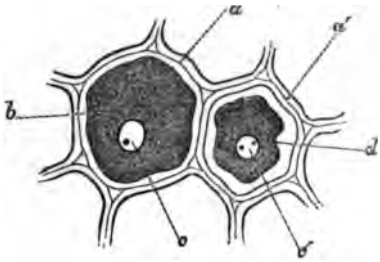


flicting statements of fact, and differences of opinion, at present irreconcileable, which future inquiry alone can rectify, and which in the mean time offer serious obstacles to an attempt at generalisation. In what follows, nothing more is intended than to bring together, under a few heads, the more general facts as yet made known respecting the formation of the animal textures, in so far as this may be done without too much anticipating details, which can only be suitably and intelligibly given in the special history of each texture.

Structure of Cells.—A vegetable cell consists of, 1. a containing wall or envelope, surrounding and enclosing the other parts, and named, from the nature of the substance of which it is composed, the *cellulose wall* (fig. VII., *a*, *a'*); 2. the *cell contents*—fluid, slimy, or of mixed nature (*b*); 3. the *nucleus* (*c*), a rounded corpuscle situated somewhere in the interior, which however disappears from many vegetable cells when they have reached maturity. In the nucleus are commonly to be seen one (*c*) or two (*c'*), rarely more, minute spots named *nucleoli*. Further, some phytologists maintain that within the cell-wall, and distinct from it, there is a delicate membrane or film immediately inclosing the cell-contents, the *primordial utricle;* but although the semblance of such an interior inveloping film may be brought into view by the application of certain re-agents (as at *d*), its

existence as a natural structure is (as already remarked, p. x) at best but doubtful.

Fig. VII. Fig. VIII.



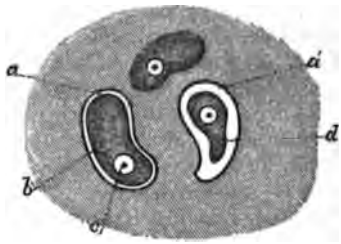


Fig. VII.—Diagram of Vegetable Cells.

a, *a'*, cellulose wall; *b*, cell-contents; *c*, *c'*, nucleus; *d*, contents shrunk away from cell-wall.

Fig. VIII.—Diagram of Animal Cells (of Cartilage).

a, *a'*, capsule; *b*, cell-contents; *c*, nucleus; *d*, cell-contents shrunk away from the capsule.

Certain animal cells have a structure comformable throughout with that just indicated as belonging to vegetable cells. Thus, the cartilage cell has an outer envelope or *capsule* (fig. VIII., *a*, *a'*), not indeed composed of cellulose but of animal matter, comparable nevertheless with the vegetable cellulose-wall, and in like manner continuous with the intercellular substance. The cell-contents (*b*), nucleus (*c*), and nucleolus or nucleoli, correspond. Finally, it has been held that there is here also a fine interior envelope corresponding to the primordial utricle of the vegetable cell, and it may be added that the agreement extends to the doubt entertained of the reality of such a membrane in either case.

But many animal cells have no exterior capsule answering to the cellulose vegetable cell-wall, and accordingly represent only the parts of the vegetable cell which are within that enclosure; that is, the nucleus and the mass of cell-contents. The chyle- lymph- and pale blood-corpuscles, the mucus- and salivary corpuscles, and the cells that first appear in the embryo, may be adduced as examples. Some cells of this description have or acquire a fine membranous envelope closely investing their surface, and corresponding to the supposed primordial utricle; but many of them appear to be naked, and to consist of a nucleus surrounded by a mass of soft matter—the so-called cell-contents—often containing solid granules which are held together by a tenacious substance. In these cases the matter at the surface is more condensed than in the interior, where not unfrequently it is more or less fluid. There is moreover a well-defined superficial outline, but there is wanting an internal contour-line marking off an envelope distinct from the contained substance. Such bodies, it is true, may sometimes show appearances indicating the presence of an envelope, when they are treated with certain chemical re-agents; but in such cases the apparent envelope may be produced by the action of the substances employed. At the same time it must be borne in mind that various cells which in their young state have no envelope, distinctly acquire one at a later stage of their existence; and this occurrence is especially to be observed in cells which are destined to form consistent structures, such as epidermis and epithelium. In these

cases the younger and more deeply-seated cells have no envelope, but acquire one before taking their place in the more superficial firm layers.*

The envelope, when present, is thin, transparent, homogeneous, flexible, and permeable to fluids. The contents differ greatly in different cells; but in those that form the first foundation of the tissues and organs in the embryo, in young cells generally, and in some cells throughout their whole existence, the contained matter is a peculiar semifluid substance, named *protoplasm*, and granular particles, mostly of a fatty nature, densely or sparingly mixed with it. The protoplasm is transparent, colourless, not diffluent, but tenacious and slimy, and under high magnifying powers is seen to contain very fine molecules. In chemical properties it agrees generally with albuminoid bodies, but in many animal cells it doubtless also includes other organic principles, especially fat and glycogenous or amyloid matter. The protoplasm is endowed with remarkable powers of contraction and motion, to be afterwards referred to. But, while certain cells, as already said, retain their primary constitution, others acquire very different matters: many contain mucus; the fat-cells are filled with oil; the cells of glands include the characteristic ingredients of the secretions; the substance of the red blood-cells is coloured, and certain cells are filled with particles of pigment. Very commonly in vegetable cells the protoplasm occupies but a small part of the space within, while the remainder is filled with watery fluid with which the protoplasm does not mingle.

Free Nuclei.—Besides the bodies which have been called cells, corpuscles having all the characters of cell-nuclei exist abundantly in various tissues, such as the membranous walls of the capillaries, the sheaths of nerve-fibres, muscular fibres, &c. But in some of these cases it is obvious, in others highly probable, that the nuclei are associated with a certain amount of protoplasm, although not in the usual mass and form of a cell.

Production of Cells.—Consistently with the present state of knowledge on this subject, the following may be assigned as the several modes in which cells and nuclei are observed to be produced in the animal system; but while the process varies in outward conditions in each of these cases, it can scarcely be doubted that it will prove to be intrinsically and fundamentally the same in all.

a. In the Ovum.—The ovum may be regarded as a cell derived from the parent. In mammalia (fig. IX., A), it has a transparent but stout external membrane (*a*); within this is the yelk (*b*), corresponding to the cell-contents; in the yelk is the germinal vesicle (*c*), including the germinal spot (*macula germinativa*), which are comparable, respectively, to the nucleus and nucleolus. The yelk consists originally of fine molecular particles held together in a transparent tenacious matrix of protoplasm; and when once fertilisation has taken place, the yelk-mass undergoes a process of subdivision or "segmentation," whereby it is fashioned into

* The existence of animal cells destitute of envelope, although more insisted on of late years, has been all along recognised in the study of cell-development, and was expressly pointed out by Schwann himself (Microscopische Untersuchungen, &c., p. 209). It has appeared to some that another name should be used to designate bodies which thus exist in a naked non-vesicular form. Brücke proposes to call them "elementary organisms," a term too cumbrous for use; as the first "shaped" products of organisation which appear in the development of all but the lowest organised beings, they might be named "protoplasts," or, as that name has been already used in a widely different sense—"monoplasts;" but, after all, seeing the universal currency of the term "cell," it is probably most convenient and best to adhere to it, with the understanding that in many cases it is used in a conventional sense.

cells, progressively increasing in number, which combine to form the first material substratum of the tissues and organs of the embryo, and are hence termed "embryonic cells."

The outline of the process is this. The germinal vesicle disappears; the yelk shrinks somewhat together, then separates into two halves (B); the first two segments divide each again into two (C), and the binary

Fig. IX.

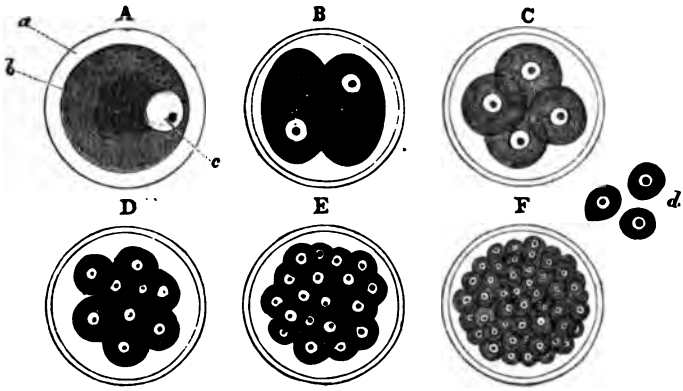


Fig. IX.—Diagrammatic Figures to illustrate the Formation of Cells within the Mammalian Ovum by Segmentation of the Yelk; magnified.

a, external membrane; *b*, yelk; *c*, germinal vesicle containing the germinal spot; *d*, embryonic cells further magnified.

division thus goes on (D, E,) pretty regularly, until a large group of small segments is produced (F). These final segments are the embryonic cells (*d*); they probably have no distinct, separable envelope; but, like other naked cells, they are formed of a nucleus and body of protoplasmic matter. The nucleus is a globule of soft pellucid substance; it may not be always discoverable in the earlier segments, being hidden by the opaque granular mass; but it soon comes into view, and it seems to play an important part in the formation of the cells. The nucleus in fact appears to initiate the process of division, by itself dividing into two halves, which, speedily acquiring full size, serve as two centres of attraction, round each of which separately the yelk-substance is gathered, and thus parted into two new segments. Possibly the substance of the vanishing germinal vesicle and spot may give rise to the first nucleus.

Fig. X.

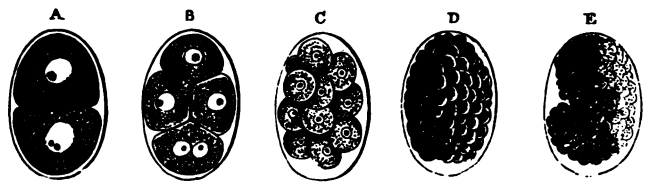


Fig. X.—Division of the Yelk of Ascaris.

A, B, C (from Kölliker), ovum of Ascaris nigrovenosa; D and E, that of Ascaris acuminata (from Bagge).

The formation of cells by segmentation of the yelk may be traced with comparative ease in the ova of many invertebrata. The accompanying figures represent the several stages of the process in small species of the ascaris worm. Figures A, B and C are from the *Ascaris nigrovenosa*, as observed by Kölliker. He found that, after the germinal vesicle had disappeared, a new nucleus with nucleolus was formed in its place. The segmentation then goes on as in the mammalian ovum, but the nuclei are visible from the first; and from appearances, such as those seen in the lowermost segments of A and B, it seems probable that the division of the nucleus is preceded by that of the nucleolus.

I may remark that I once observed the ovum of the ascaris under the microscope whilst one of the large segments was actually undergoing division. There was first a very obvious heaving motion among the granules throughout the whole mass; then ensued a constriction at the circumference, which, proceeding inwards, soon completed the division; but all this time the nuclei were quite hidden by the enveloping granular matter.

In some animals the segmentation process affects only a part of the yelk.

b. Division of free Cells.—Essentially the same process of fissiparous propagation by which the cells are multiplied within the ovum continues to take place in the embryonic cells at future stages, and in their descendants in the organs and fluids of the body throughout life. The steps of the operation have been best observed and proved in the colourless blood-corpuscles, but it takes place in various other cells (fig. XI.).

Fig. XI.

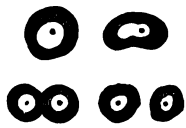


Fig. XI.—COMMENCEMENT, PROGRESS, AND RESULT, OF DIVISION OF A FREE CELL.

1. *Into two.*—The body of the cell is observed to be somewhat lengthened, and its nucleus divided into two; a constriction then begins in the middle and proceeds until the substance of the cell is parted into two halves, each of which contains a nucleus. There can be little doubt that here also the division begins with the nucleus. The colourless blood-corpuscle we presume to have no proper cell-wall, but if, as some believe, an envelope or primordial utricle is present, it is also involved in the division.

2. *Into more than two.*—The division is usually into two, as above described, but Remak has observed instances in the frog-larva of cells dividing into as many as five or six new cells; that is, after the nucleus had divided in a corresponding way. The difference in this modification of the process may simply be that whilst in the preceding case the two halves of the divided cell part from each other, and the resulting new cells undergo fresh subdivision solitarily, they in the present case remain associated in a group. Perhaps the formation of pus-corpuscles from connective tissue-corpuscles, as described by Virchow, may be an instance of this kind. Where the swollen primitive corpuscle acquires a distinct cell-membrane or capsule which incloses its progeny, the case comes to resemble the so-called "endogenous" propagation, as in cartilage, to be next described.

c. Division of inclosed Cells.—An example of this is afforded by cartilage. The cells in that tissue are surrounded by an outer capsule, which is continuous, or at least coherent, with the substance of the matrix. (Fig. XII., A). Here, as in the previous cases, there is first a division of the nucleus into two; this is followed by cleaving of the cell-body likewise into two, and thus two young cells are formed from a parent one.

So far the process is the same as before; but now a species of capsule is formed round each of the young cells (B), whilst the old one inclosing them becomes blended with the intercellular matrix, and is no longer traceable (C).

Fig. XII.

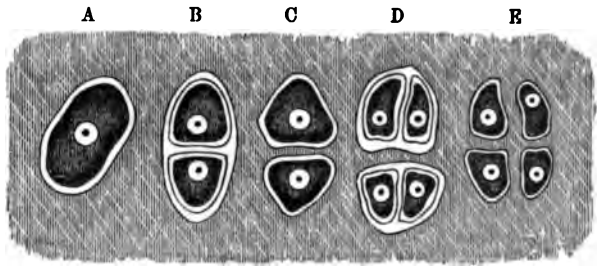


Fig. XII.—Ideal Plan of the Multiplication of Cells of Cartilage.

A, cell in its capsule; B, divided into two, each with a capsule; C, primary capsule disappeared, secondary capsules coherent with matrix; D, tertiary division; E, secondary capsules disappeared, tertiary coherent with matrix.

The new cells, in turn, divide in the same way, so as to make a group of four, each of which is surrounded by its own capsule (D), whilst the capsules of the first descent (secondary) blend with the matrix (E) like their predecessor. In certain cases the whole series of capsules may remain visible; in others, and especially in morbid conditions, the young capsules may not be formed, or may all disappear, leaving the young cells surrounded by the still conspicuous original capsule, like the yelk-segments in the ovum.

The multiplication of cells in the ovum and in cartilage, seeing that it takes place within an enclosing envelope, has been named "endogenous;" but it will be perceived that the difference between this and the division of a free cell is unimportant.

d. Multiplication of Nuclei in Cells.—Irregularly shaped cells have been found in the medullary cavities of bone (Robin and Kölliker), containing many nuclei, and such cells afford an example of the multiplication of nuclei within a cell without separation into new cells. Other multinucleated cells are formed in the spleen and pass into the blood of the splenic vein (Kölliker); but if these eventually divide into uninucleated cells, as seems most probable, the case falls under *b*, 2.

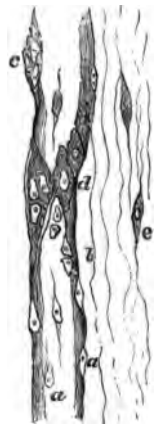
e. Multiplication of free Nuclei.—Bodies having the characters of nuclei and designated as such, commonly make their appearance in large numbers where growth or new formation of tissue is going on. There can be little doubt that these are produced by division of previously existing nuclei, uninclosed in cells but yet originally descended from cells, and probably associated with an inconspicuous amount of shapeless protoplasm. The new nuclei may continue in the same condition as those from which they immediately sprung, or it may happen that the protoplasm grows and accumulates round the groups of multiplying nuclei, each of which assumes its distinct share, and there thus results a group of new cells. The nuclei lying on the

walls of the capillary vessels have been observed to multiply in this way in the formation of new (morbid) growths, as is shown in fig. XIII.

Fig. XIII.—Capillary Vessel from a Fibroid Tumour; magnified (adapted from C. O. Weber, Virch. Arch. 1864).

a, *a*, nuclei on the wall of the capillary; *b*, nucleus after division into two; *c*, group of nuclei surrounded by protoplasm; *d*, new cells; *e*, cells of connective tissue.

Fig. XIII.



Seeing the successive generations of cells which proceed from a single one in the ovum, and the propagation of cells in a similar manner which occurs at after-periods, physiologists have been naturally led to look to the ovum for the original source to which all succeeding cells in the economy might be traced back; and, as that body is itself derived from the parent organism, it is conceived that a peculiar germinative matter is handed down from parent to offspring, and, receiving an impulse by fecundation, begins in the ovum the series of assimilative and reproductive actions which is afterwards continued throughout life. Seeing, moreover, that throughout all these operations the nucleus takes the first apparent step in the propagation of cells, and by itself increases and multiplies, that body may not unreasonably be regarded as the original depositary and subsequent representative of the germinative matter in its most characteristic type, although, no doubt, the protoplasm of the primary cell-contents is, in its degree, endowed with the same property. According to this view, all cells in the animal economy are derived from pre-existing cells, and all are to be referred back through preceding generations to the ovum. Schwann, on the other hand, maintained that cells may arise altogether independently of pre-existing cells, and that in animals this was actually the most prevalent mode of cell-production. He conceived that cells are formed out of a soft or liquid organisable matter, which he named "cyto-blastema," or simply "blastema," and which in animals that have a circulating blood is derived from that source. The blastema might be contained in cells, lodged in the interstices of cells and tissues, or deposited on the surface of growing parts; and cells might arise in any of these situations, viz., in previously existing cells, or in the interstitial and free blastema. As to the steps of the process of formation, Schwann adopted and applied to animal cells the account given by Schleiden of cell-genesis in vegetables. According to Schleiden, nuclei are first formed by aggregation of matter round nucleoli which appear in the cyto-blastema, and a cell-wall is produced by deposition and condensation of fresh matter on the nucleus, which he regarded as the generator of the cell, and therefore named the "cytoblast." Among later observers who deny the uninterrupted descent of all cells from the ovum, may be mentioned M. Robin, who believes that the embryonic cells derived from the ovum do not generate secondary cells, but suffer complete dissolution, at the same time that fresh nuclei are independently formed in their interstices from the dissolved substance.

The doctrine of independent cell-formation, which, in contradistinction to derivation from previously existing parent-cells, it has been proposed to call "equivocal cell-generation," has greatly lost ground since it was first promulgated; and perhaps it must be abandoned as regards cell-formation in the higher animals. At the same time, undue weight must not be allowed to the natural *à priori* argument against it as a case of spontaneous generation. It must further be borne in mind that in certain lichens, algæ and fungi, spores entirely constituted as cells arise, not indeed independently of a parent organism, but to all appearance not immediately from pre-existing cells or nuclei.

Motion of the Protoplasm in Cells.—In the cells of the *Vallisneria*, *Chara*, and various other plants, when exposed under the microscope, the green

coloured grains (of chlorophyll) and other small masses and corpuscles contained in the cavity, are seen to be moved along the inside of the cell-wall in a constant and determinate direction. This phenomenon appears to be of very general occurrence in the vegetable kingdom, although the movement does not always go on with the same regularity as in the instances cited. It is obviously due to a layer of protoplasm on the inner surface of the cell-wall, which enters into a peculiar flowing or undulating motion and trails the passive corpuscles along with it; but how the motion of the protoplasm itself is produced is not at all understood.

Motions are also observed in animal protoplasm; cells in form of nucleated protoplasm-masses of irregularly stellate or jagged outline, which lie in the areolar tissue and are called connective tissue-corpuscles, and similar bodies in the substance of the cornea, have been noticed slowly to change figure whilst under observation (in the tissues of the recently killed frog), shrinking in at one part of their uneven contour and extending their soft substance at another. The effect seems to be due to a contractile property of the protoplasm comparable to the contractility of muscular substance; for Kühne* has found that the substance of these protoplasm bodies contracts under the electric stimulus, and contractions may be excited in the corneal cells through the medium of fine nerves which are distributed to them, and this both by mechanical and electrical stimulation. Now the soft transparent matter named "sarcode" which constitutes the bodies of the *amœba* and *actinophrys*, and the animal part of the foraminifera and other allied organisms of simple nature exhibits similar retractile and extensile movements, and may also be made to contract by electrical excitement; and accordingly it is reckoned as an example of protoplasm by some recent observers of authority and designated by that name. It is further to be noted, however, that the varied movements of these amœbine animals are very generally accompanied by a flowing of fine particles to and fro in their pellucid substance, as if there were a thinner and more diffluent portion confined within the more firm exterior part. The movement of the fluid matter, and consequent flow of the particles carried by it, have been ascribed by some observers to an impulse caused by the contractions of the firmer portion, but there are cases in which this explanation is hardly sufficient, and the point remains in doubt.

To the same class of phenomena are probably to be referred the remarkable movements observed in the pigment-cells of the frog's skin, which have been so lucidly investigated by Professor Lister.† In these ramified cells the dark particles of pigment are at one time dispersed through the whole cell and its branches, but at another time they gather into a heap in the central part, leaving the rest of the branched cell vacant, but without alteration of its figure. In the former case the skin is of a dusky hue; in the latter, pale. The phenomenon is probably due to some kind of motion of the protoplasm, although it must be admitted that Mr. Lister has adduced arguments of considerable weight to prove that there is some impulse operating directly on the particles, and that they move independently of the surrounding matter, which he considers to be fluid. Like the movements of the protoplasm, the aggregation of the pigment molecules can be excited through the nerves, both mechanically and electrically.

Lastly, the pale blood-corpuscles and other similarly constituted cells of

* Untersuchungen über das Protoplasma und die Contractilität. 1864.
† Phil. Trans. 1858.

common occurrence exhibit changes of figure and movements of an amœbine character which seem naturally to be referred to the present head.

The fact above mentioned that these movements of cells may be excited by stimulation of the nerves is especially worthy of note, in as much as it proves that operations effected in and by cells are more or less under the governance of the nervous system. Moreover the well-known influence of mental states over the secretions, and the effects resulting from experimental stimulation of the nerves of secreting glands, although doubtless due in part to changes in the blood-vessels, seem to show that this subjection to the nervous system extends even to the chemical and physical operations which take place in secreting cells. A curious and interesting observation in proof of this is adduced by Kölliker. He found that the light of the fire-fly, *lampyris*, is emitted from cells in which albuminoid matter is decomposed with production of urate of ammonia, and that the emission of light could be brought on or rendered more vivid by electrical and other stimuli operating through the nerves.

The well-known tremulous movement which so often affects minute particles of matter, is not unfrequently observed in the molecular contents of cells; but this phenomenon depends simply upon physical conditions, and is of a totally different character from the motions of the protoplasm above referred to.

Of Cells in Relation to the Formation of Textures.—In a certain sense it might be said that the foundation of all the textures and organs of the body is formed of cells; for in the early embryo all the different parts of the body, so far as they are characterised by form and position, are made up of embryonic cells; but how the different and special characters of the fully organised textures are produced is still a matter of no little uncertainty. No doubt certain textures in their mature condition are composed of cells, which, on the supposition of continuous cell-generation, must be the progeny of the embryonic cells, although modified in character to suit them to their special destination. The epidermis, the several varieties of epithelium, and the plain or non-striated muscular tissue are examples of this. Other textures or textural elements are not made up of cells or formed immediately from cells, as, for example, the fibres of connective tissue, which are produced in intercellular substance. But there remain cases of tissue-formation in which, whilst it is generally admitted that cells or nuclei take part, it is not agreed to what extent or in what precise mode these bodies share in the process: the development of the fibres of voluntary muscles and nerves afford an illustration of this, as will be afterwards shown in its proper place. Accordingly the reasonableness of certain limitations and qualifications of the doctrine of tissue-development from cells has been recognised by judicious histologists even from its first promulgation.

Of the changes which cells or their elements undergo in the formation of tissues, or afterwards in the exercise of their functions when constituting part of the living organism, the following are what may be considered as best ascertained; and it is to be observed that the same cell may undergo more than one of the changes indicated.

1. Cells may increase in size and change their figure. When a cell grows equally or nearly so in all directions, it preserves its globular shape; but more commonly the growth is greater in one dimension than in another, and then the cell becomes flattened, in which case it may remain as a round disk or change into an oval, fusiform, or strap-shaped figure. When

growing cells meet one another, they generally become angular or polyhedral; and this change may be combined with elongation into the prismatic or flattening into the tabular form, as exemplified in the columnar and scaly varieties of epithelium. A more remarkable change of figure occurs in those instances where a cell sends out branches at various points of its circumference, as happens with certain varieties of pigment-cells (fig. XIV.), connective tissue-corpuscles, and nerve-cells. Of course when the changes of figure are accompanied by an absolute increase in size, there must be assumption of new matter by the cell. The nucleus seems to be less subject to alteration in size and shape. It may grow somewhat larger as the cell increases, especially at first; thus it enlarges and flattens in epithelium cells. In the cells of non-striated muscle it becomes oblong or rod-shaped. Sometimes it disappears, as in the flattened cells of the cuticle.

Fig. XIV.

Fig. XIV.—Ramified and Fusiform Cells, from the tissue of the Choroid Coat of the Eye; magnified 350 diameters (after Kölliker).

a, cells with pigment; *b*, colourless fusiform cells.

2. Whilst the above-described changes of figure are going on, the cell wall may acquire increased density and strength; and in a flattened cell, when much extended, the opposite sides may cohere so as to convert it into a scale. The thickening of the cell-membrane may take place by deposition of new matter on its inner surface, as in vegetable cells, or on the outside, as is probably the case in the partial thickening of the cell-wall in certain forms of intestinal epithelium; but there are cases in which it is difficult to determine in what way the change is affected. The substance of a cell thus condensed may have changed more or less in chemical nature, as in the cuticle, where the cells, while deep-seated and recently formed, are soluble in acetic acid, but as they rise to the surface lose this property and acquire a horny character.

3. Changes may take place in the cell-contents. Granular matter in cells may be dissolved and consumed, as is well seen in the formation of blood-corpuscles from granular cells in the oviparous vertebrata. On the other hand, new matters may appear, as fat and pigment within the adipose and pigmentous cells, and the peculiar constituents of certain secretions in the cells of secreting organs, in which last case the cells may burst and discharge their contents. Lastly, the process may take on more of a plastic and organising character, as in the generation of young cells, already described, and the formation of the spontaneously moving bodies named spermatozoa, which are produced from the nuclei of cells.

These plastic changes are equally unexplained with the other alterations of form and structure which accompany the production and metamorphoses of cells. As regards the changes in the quantity and chemical nature of the contained matter, it may be remarked, that the introduction of new matter into a cell is so far a phenomenon of imbibition, and, as such, must be to a certain extent dependent on the endosmotic effect produced by the substance already within the cell, and on the comparative facility with which the matter to be introduced is imbibed and transmitted by the permeable cell-wall. Some substances, moreover, being more readily imbibed than others, the quality as well as the quantity of the imbibed material will be so far

determined by the same circumstances. Thus, uric acid, known to be present in minute quantity in the blood, is gathered up by the cells of the kidneys, and other chemical compounds existing in the circulating fluid may be segregated in like manner by cells, to be discharged by excretion. Also in the converse operation of absorption of aliment, the cells of the intestinal epithelium become charged with particles of fat. But, while an alteration in the contents of a cell may be thus brought about by the imbibition of one kind of matter in preference to another, the contained substance may be also changed in its qualities by a process of conversion taking place within the cell.

4. Cells ultimately present differences in their relations to each other.

a. They may remain isolated, as in the instance of the corpuscles of blood, chyle, and lymph, and those formed in certain secretions.

b. They may be united into a continuous tissue, by means of a cementing intercellular substance; the epithelium and cuticle, the nails and hairs, afford instances of this. In cartilage, where this occurs, the capsules of the cells may become more or less blended with the intercellular substance.

c. The parietes of neighbouring cells meet at particular points, and, absorption taking place, their cavities become united. It is supposed that ramified cells may thus open into one another; and Schwaun conceives that the networks of capillary vessels originate in this way.

Intercellular Substance.—Of the matter which lies between cells—the intercellular substance—and its relation to them, it may be observed that sometimes it is in very small quantity, and seems merely to cement the cells together, as in epidermis and epithelium; at other times it is more abundant, and forms a sort of matrix in which the cells are imbedded, as in cartilage. It is homogeneous, translucent, and firm in most cartilages, and pervaded by fibres in yellow cartilage. In connective tissue it consists of fibres, with soft interstitial matter, which is scanty in the denser varieties, but abundant in the lax tissue of the umbilical cord; in bone the intercellular substance is calcified and mostly fibrous. As to the production of the intercellular substance, there can be little doubt that in cartilage it is derived from the cells. Formed as capsules round the cells by excretion from their surface, or by conversion of their proper substance, and being blended into a uniform mass, it accumulates while the cells multiply, and while fresh material is supplied to them from the blood, which they convert into chondrinous substance. Kölliker supposes that, in like manner, simple membrane, such as the *membranæ propriæ* of gland-ducts, may be produced by excretion from a series of cells; in which case such membranes would come under the same description as intercellular substance. The source of the intercellular substance is in other cases not so apparent, but it may be presumed that the cells have some influence in its nutrition and maintenance.

From what has been said it will be obvious that cells and nuclei play an important part in the growth of textures, and probably in nutrition. The former process is usually accompanied by a great multiplication of cells or nuclei, the peculiar constituent of which—the protoplasm—seems to be specially endowed with the faculty of propagation by division, and of increase by appropriating and converting new matter. It is conceivable that in this way it may serve for the extension of growing tissue and the development of structural elements from the crude materials of growth. Again, in the nutrition of a mass of tissue the crude material may undergo preparation by the cells or nuclei that lie in the interstices of the structure.

The existence of this protoplasmic germinative substance is very general, perhaps indeed universal, in the animal and vegetable kingdoms. But whilst in the great

majority of organic beings it assumes the form of a nucleated cell (protoplast, or monoplast), as the first condition of their organised structure, in simpler modes of life and organisation it is not subject to the same limitation of form and mass. In the *mycetozoa* (*myxomycetes*), a curious tribe, heretofore mostly reckoned among the fungi, but standing as it were in the debateable ground between the animal and vegetable kingdoms, the protoplasm is extended into reticular masses, or irregularly anastomosing trains, spread over the surface of bark and other bodies to which it parasitically clings; whilst in vibrios and some other infusorial animalcules of the simplest kind, it appears as fine molecular particles; but it is most probably derived from parents in all instances, however minute and apparently insignificant these may be.

Professor Beale proposes to distinguish the matter of organised bodies into two kinds, viz., "germinal matter"—which comprehends the active matter of cells and nuclei, and appears to correspond with what has been already described as protoplasm—and "formed material," under which term he includes all the structural elements and intercellular substances lying outside and between cells, the cell-wall itself when present, and certain products, not germinative, which may be included in the cell-contents. "Germinal matter" grows and increases, and is converted into "formed material;" and all "formed material" has passed through the condition of "germinal matter." In nutrition, according to Dr. Beale, "pabulum does not pass through the cell-wall to become altered by the action of the cell, but certain of its constituents are converted into germinal matter,—the living substance, which becomes tissue, or is changed into substances which form the constituents of the secretions." Formed material may be endowed with peculiar and important properties, but is destitute of the power of producing matter like itself,—"it has no power to *produce* structure or to alter itself."* I presume it is not meant by this to imply that "formed material" is incapable of undergoing further organisation; for otherwise the proposition would be in contradiction to well-known facts, such as the formation of fibres in the matrix of cartilage, &c.

Professor Bennett considers that organisation begins with molecules or granules of various composition and endowments. These are of two kinds—*histogenetic*, formed by precipitation from fluids, and *histolytic*, derived from the disintegration of previously formed tissues. Molecules of disintegration may in peculiar circumstances become the basis of matter which undergoes development, so that histolytic, or disintegration particles of one period become the histogenetic or formation molecules of another. Certain molecules are endowed with the power of active movement, and the motions in cells and tissues depend upon them; they are mutually attracted by a molecular force, and thus unite to produce cells and higher forms of tissue.†

Molecules and granules are, no doubt, more elementary forms of organisable substance than cells; still it is matter of observation that in the early embryo and in the production of certain tissues, these particles in the first instance unite to form cells. This, Dr. Bennett by no means denies, only he regards the formation of cells as of subordinate moment in the general process of organisation. For my own part I am disposed to think that in the process of organisation, as distinguished from its result, the cognisable form and mass of the organisable material, whether as cell or molecule, are of altogether subordinate consideration to the nature of its substance.

NUTRITION AND REGENERATION OF THE TEXTURES.

Nutrition.—The tissues and organs of the animal body, when once employed in the exercise of their functions, are subject to continual loss of material, which is restored by nutrition. This waste or consumption of matter, with which, so to speak, the use of a part is attended, takes place in different modes and degrees in different structures. In the cuticular

* On the Structure of the Simple Tissues of the Human Body, &c., 1861; and Archives of Medicine for 1862.

† For a brief but lucid exposition of his views on this subject, see Dr. Bennett's paper On the Molecular Theory of Organisation, as given in abstract in the Proceedings of the Royal Society of Edinburgh for the 1st of April, 1861.

textures the old substance simply wears away, or is thrown off at the surface, whilst fresh material is added from below. In muscular texture, on the other hand, the process is a chemical or chemico-vital one; the functional action of muscle is attended with an expenditure of moving force, and a portion of matter is consumed in the production of that force; that is, it undergoes a chemical change, and being by this alteration rendered unfit to serve again is removed by absorption. The amount of matter changed in a given time, or, in other words, the rapidity of the nutritive process, is much greater in those instances where there is a production and expenditure of force, than where the tissue serves merely passive mechanical purposes. Hence, the bones, tendons, and ligaments are much less wasted in exhausting diseases than the muscles, or than the fat, which is consumed in respiration, and generates heat. Up to a certain period, the addition of new matter exceeds the amount of waste, and the whole body, as well as its several parts, augments in size and weight: this is "growth." When maturity is attained, the supply of material merely balances the consumption; and, after this, no steady increase takes place, although the quantity of some matters in the body, especially the fat, is subject to considerable fluctuation at all periods of life.

It would be foreign to our purpose to enter on the subject of nutrition in general; we may, however, briefly consider the mode in which the renovation of substance is conceived to be carried on in the tissues.

The material of nutrition is immediately derived from the plasma of the blood, or liquor sanguinis, which is conveyed by the blood-vessels, and transudes through the coats of their capillary branches; and it is in all cases a necessary condition that this matter should be brought within reach of the spot where nutrition goes on, although, as will immediately be explained, it is not essential for this purpose that the vessels should actually pass into the tissue.

In cuticle and epithelium, the nutritive change is effected by a continuance of the process to which these textures owe their origin. The tissues in question being devoid of vessels, nutrient matter, or blastema, is furnished by the vessels of the true skin, or subjacent vascular membrane; this matter is appropriated by young cells derived most probably from pre-existing ones. These new cells enlarge, alter in figure, often also in chemical nature, and, after serving for a time as part of the tissue, are thrown off at its free surface.

But it cannot in all cases be so clearly shown that nutrition takes place by a continual formation and decay of the structural elements of the tissue; and it must not be forgotten, that there is another conceivable mode in which the renovation of matter might be brought about, namely, by a molecular change which renews the substance, particle by particle, without affecting the form or structure; by a process, in short, which might be termed "molecular renovation." Still, although conclusive evidence is wanting on the point, it seems probable that the crude material of nutrition first undergoes a certain elaboration or preparation through the agency of cells and nuclei disseminated in the tissue; which may serve as centres of assimilation and increase, as already explained.

Office of the Vessels.—In the instance of cuticle and epithelium, no vessels enter the tissue, but the nutrient fluid which the subjacent vessels afford penetrates a certain way into the growing mass, and the cells continue to assimilate this fluid, and pass through their changes at a distance from, and independently of, the blood-vessels. Whether, in such cases, the whole of the

residuary blastema remains as intercellular substance, or whether a part is again absorbed into the vessels, is not known. In other non-vascular tissues, such as articular cartilage, the nutrient fluid is doubtless, in like manner, conveyed by imbibition through their mass, where it is then attracted and assimilated. The mode of nutrition of these and other non-vascular masses of tissue may be compared, indeed, to that which takes place throughout the entire organism in cellular plants, as well as in polypes and some other simple kinds of animals, in which no vessels have been detected. But even in the vascular tissues the case is not absolutely different; in these, it is true, the vessels traverse the tissue, but they do not penetrate into its structural elements. Thus the capillary vessels of muscle pass between and around its fibres, but do not penetrate their inclosing sheaths; still less do they penetrate the fibrillæ within the fibre; these, indeed, are much smaller than the finest vessel. The nutrient fluid, on exuding from the vessels, has here, therefore, as well as in the non-vascular tissues, to permeate the adjoining mass by transudation, in order to reach these elements, and yield new substance at every point where renovation is going on. The vessels of a tissue have, indeed, been not unaptly compared to the artificial channels of irrigation which distribute water over a field; just as the water penetrates and pervades the soil which lies between the intersecting streamlets, and thus reaches the growing plants, so the nutritious fluid, escaping through the coats of the blood-vessels, must permeate the intermediate mass of tissue which lies in the meshes of even the finest vascular network. The quantity of fluid supplied, and the distance it has to penetrate beyond the vessels, will vary according to the proportion which the latter bear to the mass requiring to be nourished.

We have seen that in the cuticle the decayed parts are thrown off at the free surface; in the vascular tissues, on the other hand, the old or effete matter must be first reduced to a liquid state, then find its way into the blood-vessels, or lymphatics, along with the residual part of the nutritive plasma, and be by them carried off. But, in certain cases, the mode of removal of the old matter is not clear; as, for example, in the crystalline lens, which is destitute of vessels, and grows by deposition of blastema and formation of cells at its surface; here we should infer that the oldest parts were nearest the centre, and if we suppose them to he changed in nutrition, it is puzzling to account for their removal.

From what has been said, it is clear that the vessels are not proved to perform any other part, in the series of changes above described, beyond that of conveying matter to and from the scene of nutrition; and that this, though a necessary condition, is not the essential part of the process. The several acts of assuming and assimilating new matter, of conferring on it organic structure and form, and of disorganising again that which is to be removed, which are so many manifestations of the metabolic and plastic properties already spoken of, are performed beyond the blood-vessels. It is plain, also, that a tissue, though devoid of vessels, and the elements of a vascular tissue, though placed at an appreciable distance from the vessels, may still be organised and living structures, and within the dominion of the nutritive process. How far the sphere of nutrition may, in certain cases, be limited, is a question that still needs further investigation; in the cuticle, for example, and its appendages, the nails and hairs, which are placed on the surface of the body, we must suppose that the old and dry part, which is about to be thrown off or worn away, has passed out of the limits of nutritive influence; but to what distance beyond the vascular surface of the skin the province of nutrition extends, has not been determined.

Regeneration.—When part of a texture has been lost or removed, the

loss may be repaired by regeneration of a new portion of tissue of the same kind ; but the extent to which this restoration is possible is very different in different textures. Thus, in muscle, a breach of continuity may be repaired by a new growth of connective tissue ; but the lost muscular substance is not restored. Regeneration occurs in nerve ; in bone it takes place readily and extensively, and still more so in fibrous, areolar, and epithelial tissue. The special circumstances of the regenerative process in each tissue will be considered hereafter ; but we may here state generally, that, as far as is known, the reproduction of a texture is effected in the same manner as its original formation.

In experimental inquiries respecting regeneration, we must bear in mind, that the extent to which reparation is possible, as well as the readiness with which it occurs, is much greater in many of the lower animals than in man. In newts, and some other cold-blooded vertebrata, indeed (not to mention still more wonderful instances of regeneration in animals lower in the scale), an entire organ, a limb, for example, is readily restored, complete in all its parts, and perfect in all its tissues.

In concluding what it has been deemed advisable in the foregoing pages to state respecting the development of the textures, we may remark, that, besides what is due to its intrinsic importance, the study of this subject derives great interest from the aid it promises to afford in its application to pathological inquiries. Researches which have been made within the last few years, and which are still zealously carried on, tend to show that the structures which constitute morbid growths are formed by a process analogous to that by which the natural or sound tissues are developed : some of these morbid productions, indeed, are in no way to be distinguished from areolar, fibrous, cartilaginous, and other natural structures, and have, doubtless, a similar mode of origin ; others, again, as far as yet appears, are peculiar in structure and composition, but still their production is with much probability to be referred to the same general process. The prosecution of this subject, however, does not fall within the scope of the present work.

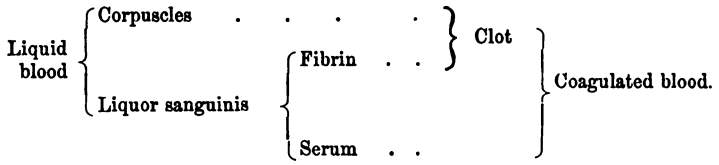
THE BLOOD.

PHYSICAL AND ORGANIC CONSTITUTION.

The most striking external character of the blood is its well-known colour, which is florid red in the arteries, but of a dark purple or modena tint in the veins. It is a somewhat clammy and consistent liquid, a little heavier than water, its specific gravity being 1052 to 1057 ; it has a saltish taste, a slight alkaline reaction, and a peculiar faint odour.

To the naked eye the blood appears homogeneous ; but when examined with the microscope, either while within the minute vessels, or when spread out into a thin layer upon a piece of glass, it is seen to consist of a transparent colourless fluid, named the "lymph of the blood," "liquor sanguinis," or "plasma," and minute solid particles or corpuscles immersed in it. These corpuscles are of two kinds, the red and the colourless : the former are by far the most abundant and have been long known as "the red particles," or "globules," of the blood ; the "colourless," "white," or "pale corpuscles," on the other hand, being fewer in number and less conspicuous, were later in being generally recognised. When blood is drawn from the vessels, the liquor sanguinis separates into two parts ;— into fibrin, which becomes solid, and a pale yellowish liquid named *serum*. The fibrin in solidifying involves the corpuscles and forms a red consistent

mass, named the clot or *crassamentum* of the blood, from which the serum gradually separates. The relation between the above-mentioned constituents of the blood in the liquid and the coagulated states may be represented by the subjoined scheme :—



Red Corpuscles.—These are not spherical, as the name "globules," by which they have been so generally designated, would seem to imply, but flattened or disk-shaped. Those of the human blood (fig. XV., 1, 2) have a nearly circular outline, like a piece of coin, and most of them also present a shallow cup-like depression or dimple on both surfaces; their usual figure is, therefore, that of biconcave disks. Their magnitude differs somewhat even in the same drop of blood, and it has been variously assigned by authors; but the prevalent size may be stated at from $\frac{1}{3500}$th to $\frac{1}{3200}$th of an inch in diameter, and about one-fourth of that in thickness.

Fig. XV.

Fig. XV.—Red Corpuscles of Human Blood; magnified about 500 diameters (Wagner).

1, shows depression on the surface; 2, a corpuscle seen edgeways; 3, red corpuscles altered by exposure.

In mammiferous animals generally, the red corpuscles are shaped as in man, except in the camel tribe, in which they have an elliptical outline. In birds, reptiles, and most fishes, they are oval disks with a central elevation on both surfaces (fig. XVI., from the frog), the height and extent of which, as well as the proportionate length and breadth of the oval, vary in different instances, so that in some osseous fishes the elliptical form is almost shortened into a circle. The blood corpuscles of invertebrata, although they (except in some of the red-blooded annelides) want the red colour, are also, for the most part, flattened or disk-shaped; being in some cases circular, in others oblong, as in the larvæ of aquatic insects. Sometimes they appear granulated on the surface like a raspberry, but this is probably due to some alteration occurring in them.

Fig. XVI.

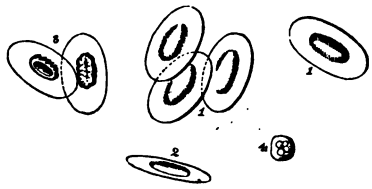


Fig. XVI.—Blood Corpuscles of the Frog; magnified about 500 diameters.

1, shows their broad surface; 2, one seen edgeways; 3, shows the effect of weak acetic acid; the nucleus has become distinct; 4, a colourless or lymph corpuscle (from Wagner).

The size of the corpuscles differs greatly in different kinds of animals; it is greater in birds than in mammalia, and largest of all in the naked amphibia. They are for the most part smaller in quadrupeds than in man; in the elephant, however, they are larger, being $\frac{1}{2700}$th of an inch, which is the largest size yet observed in the blood-corpuscles of any mammiferous

animal: the goat was long supposed to have the smallest, viz., about $\frac{1}{6400}$th of an inch; but Mr. Gulliver has found that they are much smaller in the Meminna and Napu musk deer, in which animals they are less than $\frac{1}{12000}$th of an inch. In birds they do not vary in size so much; from Mr. Gulliver's very elaborate tables of measurement it appears that they range in length from about $\frac{1}{1700}$th to $\frac{1}{2600}$th of an inch; he states that their breadth is usually a little more than half the length, and their thickness about a third of the breadth or rather more. He found a remarkable exception in the corpuscles of the snowy owl, which measure $\frac{1}{1350}$th of an inch in length; and are only about a third of this in breadth. In scaly reptiles they are from $\frac{1}{1500}$th to $\frac{1}{1200}$th of an inch in length; in the naked amphibia they are much larger: thus, in the frog they are $\frac{1}{1000}$th of an inch long, and $\frac{1}{1700}$th broad; in the salamander they are larger still; but the largest yet known in any animal are those of the proteus, which are $\frac{1}{400}$th of an inch in length, and $\frac{1}{727}$th in breadth; the siren, which is so much allied to the proteus in other respects, agrees with it also in the very large size of its blood-corpuscles; they measure $\frac{1}{420}$th of an inch in length, and $\frac{1}{760}$th in breadth. In the skate and shark tribe the corpuscles resemble those of the frog, in other fishes they are smaller.

From what has been stated, it will be seen that the size of the blood-corpuscles in animals generally is not proportionate to the size of the body; at the same time Mr. Gulliver remarks, that "if we compare the measurements made from a great number of different species *of the same order*, it will be found that there is a closer connection between the size of the animal and that of its blood-corpuscles than has been generally supposed;" and he has pointed out at least one example of a very natural group of quadrupeds, the ruminants, in which there is a gradation of the size of the corpuscles in relation to that of the body.

C. Schmidt, on account of the varying size which the corpuscles present, in dependence upon the density of the liquor sanguinis, has subjected them to repeated measurements when *dried*, in a very thin layer upon slips of glass. It has been thus found that from 95 to 98 per cent. present the same magnitude.

Structure.—The large corpuscles of the frog and salamander, when drawn from the vessels and placed under the microscope, appear to consist of a thin, transparent, vesicular *envelope*, enclosing a solid oval *nucleus* in the centre, with a quantity of softer *red-coloured matter* disposed round the nucleus and filling up the space between it and the envelope. When exposed to the action of weak acetic acid, (fig. XVI.,[3]) the colouring matter is speedily extracted, and the nucleus becomes distinct, whilst the envelope is rendered so faint as to be scarcely visible; but its outline may be still brought into view by adding solution of iodine, which gives it colour and opacity. Pure water extracts the colour and distends the corpuscle by imbibition, altering its shape from oval to round, and making the nucleus more conspicuous. Often in these circumstances the nucleus is displaced from its central position, and it may even be extruded altogether, as if by bursting of the corpuscle, which then appears flattened and colourless, and in this condition is generally supposed to represent only the ruptured and empty envelope; but even with the help of iodine, no rent can be perceived in it. For this and also for other reasons some think that what remains behind after escape of the nucleus is really the soft and now colourless substance of the corpuscle, and that it has no distinct envelope. On the opposite view it is suggested that the absence of apparent laceration in the envelope is owing

to plasticity of its substance ; and the case has been compared to the section of a soap-bubble into two or more without destruction or collapse. Dr. W. Roberts,* who makes this comparison, has brought forward some curious observations on the effects of solutions of magenta and of tannin on the corpuscles of man and various animals, which seem to him to speak for the presence of an envelope. It must, I think, be admitted that the question is open to debate, but it could not be settled by even a much more extended discussion than could suitably be introduced here.

The distension by water is caused by the thinner exterior fluid passing by endosmosis into the thicker matter of the corpuscle; and precisely the opposite effect may be produced by immersing the corpuscles in a fluid of a sufficiently high degree of concentration, so as to cause the predominant current to pass from within outwards. Accordingly, on using a strong solution of salt or of sugar, the corpuscles will shrink and become thinner ; and, no doubt, the variations in plumpness which they often naturally present, are owing to differences in the degree of concentration of the surrounding liquid. The nucleus (fig. XVI.,[3]) is rather more than a third of the length of the corpuscle ; it appears, especially after being exposed to the action of vinegar, to be composed of tolerably large granules, and, when so treated at least, it is quite free from colour. But it must be remembered that it is only after exposure of the corpuscles that a nucleus becomes apparent ; nothing of the kind is observable when they are seen within the vessels, so that some think the nuclei are formed by a sort of precipitation or consolidation in the substance of the corpuscles when they are withdrawn from the animal. The envelope is supposed to be an exceedingly fine, homogeneous, and pellucid membrane. The coloured content of the corpuscle is a pale reddish matter; not liquid but obviously of a soft and yielding nature, for the corpuscles alter their shape on the slightest pressure, as is beautifully seen while they move within the vessels; they are also elastic, for they readily recover their original form again. It must be remarked that the blood-corpuscles when viewed singly appear very faintly coloured, and it is only when collected in considerable quantity that they produce a strong deep red.

A structure similar to that shown in the large blood-disks of amphibia, may be demonstrated in many other instances, and by analogy has been inferred to exist in all, man not excepted. But although the blood-corpuscles of man and mammalia are nucleated in the early stages of their formation, it is now satisfactorily established that in their perfect or final condition they are destitute of nuclei. As to an envelope, some observers, who admit its presence in the red corpuscles of oviparous vertebrata, doubt of its existence in mammalian blood-disks. From long continued and careful observation, Mr. Gulliver concludes that the mammalian red corpuscle consists of two parts ; viz., 1, a tegumentary membranous frame of colourless, homogeneous, structureless substance, containing, 2, a semi-fluid, viscid, coloured matter. The effect of water is to extract the easily

* Proceedings of the Royal Society, vol. xii. p. 481. Hensen, who also holds to the belief of an envelope, thinks that the red corpuscle of the frog contains protoplasm in a layer next the envelope, and also round the nucleus, and elsewhere a coloured intracellular fluid. His observations show that the contents may be separated into two substances, but they are by no means conclusive as to the alleged natural distribution of these substances within the corpuscle. (Zeitschr. für wiss. Zoologie, 1861, p. 263.) For some interesting observations by Dr. W. Addison, F.R.S., on the curious effects produced on red blood-corpuscles by immersion in sherry-wine, see Proceedings of the Royal Society, Dec. 8, 1859.

soluble coloured substance from the tegumentary frame, which is insoluble, and remains behind, shrunk to about two-thirds of its original diameter. To me the human blood-corpuscles, when deprived of their coloured part by means of distilled water, and subsequently treated with solution of iodine, appear under the microscope like somewhat thick shrunken sloughs.

The human blood-corpuscles, as well as those of the lower animals, often present deviations from the natural shape, which are most probably due to causes acting after the blood has been drawn from the vessels, but in some instances depend upon abnormal conditions previously existing in the blood. Thus, it is not unusual for many of them to appear indented or jagged at the margin, when exposed under the microscope, (fig. xv., 3) and the number of corpuscles so altered often appears to increase during the time of observation. This is, perhaps, the most common change; but they may become distorted in various other ways, and corrugated on the surface; not unfrequently one of their concave sides is bent out, and they acquire a cup-like figure. It is even a question with some observers, whether the biconcave figure which the corpuscles generally present may not be due to a distension of the circumferential part of an originally flat disk. Mr. Gulliver made the curious discovery, that the corpuscles of the Mexican deer and some allied species present very singular forms, doubtless in consequence of exposure; the figures they assume are various, but most of them become lengthened and pointed at the ends, and then often slightly bent, not unlike caraway-seeds.

The red disks, when blood is drawn from the vessels, sink in the plasma; they have a singular tendency to run together, and to cohere by their broad surfaces, so as to form by their aggregation cylindrical columns, like piles or rouleaus of money, and the rolls or piles themselves join together into an irregular network (fig. xvii.). In a few moments after this has taken place, a heaving or slowly oscillating motion is observable in the mass, and the rolls may then become broken up, and the corpuscles more or less completely disjoined (Jones). Generally the corpuscles separate on a slight impulse, and they may then unite again. The phenomenon is probably of a physical kind: it will take place in blood that has stood for some hours after it has been drawn, and also when the globules are immersed in serum in place of liquor sanguinis.

Fig. XVII.

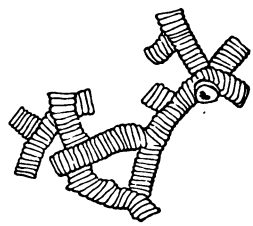


Fig. XVII.—Red Corpuscles collected into Rolls (after Henle).

By processes, which need not here be detailed, Vierordt and Welcker have estimated the number of red corpuscles in a cubic millimetre of human blood. The former assigns it at upwards of 5,000,000; the latter at 5,000,000 in the male, and 4,500,000 in the female.

Pale or colourless Corpuscles (fig. xviii.).—These are comparatively few in number, of a rounded and slightly flattened figure, rather larger in man and mammalia than the red disks, and varying much less than the latter in size and aspect in different animals. In man (during health) the proportion of the white corpuscles to the red is about 2 or 3 to 1000. This proportion is diminished by fasting and increased after a meal, especially of albuminous food. Their number compared with the red corpuscles is said to be greater

in venous than arterial blood; and it is much greater in the blood of the splenic and hepatic veins than in venous blood generally. They are destitute of colour, finely granulated on the surface, and specifically lighter than the red corpuscles. The large corpuscles are less distinctly granular than the small. Water has little effect on them; acetic acid brings speedily into view a nucleus, which frequently presents a reddish tint (Virchow and Kölliker), consisting sometimes of one, but more commonly of two, three, or four, large clear granules (fig. XVIII., 2, 3). The number of apparent nuclei is said by Mr. Wharton Jones to depend upon the strength of the acetic acid employed; if the acid is much diluted, only one is seen; if strong acid is used, the nucleus breaks up into three or four nuclear-looking particles. Under the action of the acid the circumferential part of the corpuscle becomes clear of granules and pellucid, and swells up by imbibition with a regular and well-defined outline, which has been taken for the indication of a fine envelope, but conclusive evidence on this point is wanting. The clear substance is eventually dissolved, the nucleus remaining.

Fig. XVIII.

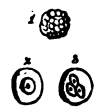


Fig. XVIII. — Pale Corpuscles of Human Blood; magnified about 500 diameters.

1, natural aspect; 2 and 3, acted on by weak acetic acid, which brings into view the single or composite nucleus.

The pale corpuscles frequently undergo curious changes of shape, sending out processes into which the granules enter, and retracting them again; in short, exhibiting phenomena which have been aptly compared to the movements of an amœba.

Albuminous granules and molecules of a fatty nature occur in the blood in varying numbers; sometimes very scantily, or not at all, but the latter sometimes in vast numbers so as to give the serum a turbid, milky appearance. These are probably derived directly from the chyle (its "molecular base"), and they are especially seen in the blood of herbivora, in sucking animals, and in pregnant women.

Occasional Elements.—Besides the foregoing, the blood occasionally presents the following constituents:—(1) bodies like cells, enclosing blood-corpuscles, noticed by Ecker and Kölliker in the blood of the spleen and hepatic vessels, and elsewhere. (2) Pigmentous granule-cells. (3) Pale, fine-granular, roundish aggregations, in the splenic blood. (4) Peculiar bodies, three or four times larger than the pale corpuscles, but in other respects resembling them. (5) Caudate, pale, or pigmentous cells. (6) Fibrinous coagula.

Liquor Sanguinis, or Plasma.—This is the pale clear fluid in which the corpuscles are naturally immersed. Its great character is its strong tendency to coagulate when the blood is withdrawn from the circulating current, and on this account it is difficult to procure it free from the corpuscles. Nevertheless, by filtering the slowly coagulable blood of the frog, as was first practised by Müller, the large corpuscles are retained by the filter, while the liquor sanguinis comes through in perfectly clear and colourless drops, which, while yet clinging to the funnel, or after they have fallen into the recipient, separate into a pellucid glassy film of fibrin, and an equally transparent diffluent serum. When human blood is drawn in inflammatory diseases, as well as in some other conditions of the system, the red particles separate from the liquor sanguinis before coagulation, and leave the upper part of the liquid clear. In this case, however, the plasma is still mixed with the pale corpuscles, which, being light, accumulate at the top. On coagulation taking place in these circumstances, the upper part of

the clot remains free from redness, and forms the well-known "buffy coat" so apt to appear in inflammatory blood. Now, in such cases, a portion of the clear liquor may be taken up with a spoon, and allowed to separate by coagulation into its fibrin and serum, so as to demonstrate its nature. Professor Andrew Buchanan has pointed out another method of separating the liquor sanguinis from the red corpuscles, which I have repeatedly tried with success; it consists in mixing fresh-drawn blood with six or eight times its bulk of serum, allowing the red particles to subside, and then decanting the supernatant fluid, and filtering it through blotting-paper; the admixture of serum delays coagulation, and a great part of the liquor sanguinis, of course diluted, and usually more or less coloured, passes through the filter, and subsequently coagulates.

Coagulated plasma, whether obtained from buffy blood, or exuded on inflamed surfaces, presents, under the microscope, a multitude of fine filaments confusedly interwoven, as in a piece of felt; but these are more or less obscured by the intermixture of corpuscles and fine granules, the former having all the characters of the pale corpuscles of the blood. The filaments are no doubt formed by the fibrin, as it solidifies in the coagulation of the liquor sanguinis.

Blood may be freed from fibrin by stirring it with a bundle of twigs, which entangle the fibrin as it concretes.

CHEMICAL COMPOSITION OF THE BLOOD.

The blood is slightly alkaline in reaction. Carbonic acid, oxygen, and nitrogen gases may be extracted from it, by exhaustion (Magnus), by heating after dilution with water (L. Meyer), or by both these means combined (Setschenow). Carbonic acid is yielded in largest proportion, oxygen next, and nitrogen least. The nitrogen appears to be simply retained by absorption, the other two partly by absorption and partly by weak chemical combination. The combined oxygen is probably in great part held by some component of the red corpuscles; the carbonic acid, which is obtained in larger measure from serum, seems to be combined partly with carbonate of soda in a bicarbonate, and partly with phosphate of soda, from both of which combinations it can be set loose by heat and reduction of pressure. Arterial blood yields more oxygen and less carbonic acid than venous blood.

On being evaporated, 1000 parts of blood yield, on an average, about 790 of water and 210 of solid residue. This residue has nearly the same ultimate composition as flesh. A comparative examination of dried ox-blood and dried flesh (beef), by Playfair and Boeckmann, gave the following mean result:—

	Flesh.	*Blood.*
Carbon	51·86	51·96
Hydrogen	7·58	7·25
Nitrogen	15·03	15·07
Oxygen	21·30	21·30
Ashes	4·23	4·42

Red Corpuscles.—The specific gravity of the red corpuscles, in a moist

state, is calculated at 1·088. They consist, as already stated, of an insoluble, colourless tegumentary substance (envelope) and an included red matter, which is soluble and separable by water. The former doubtless belongs to the group of albuminoids or protein-bodies, and some have regarded it as a species of fibrin, but in truth it cannot be specifically characterised. In numerical statements of blood-analyses it is reckoned along with the globulin. The soluble coloured ingredient, for which it is convenient to retain the old name of *cruor*, is separable into two substances,—one named *globulin*, of itself colourless, and very nearly allied to albumen in its nature; the other a colouring principle, named *hæmatin* or *hæmatosin*, which imparts redness to the first; and hence the cruor is often also designated as *hæmato-globulin*. These may be separated by the following process:—

Blood deprived of fibrin by stirring is mixed with at least four times its bulk of saturated solution of sulphate of soda, and thrown upon a filter; a few of the corpuscles pass through with the liquid, but the greater part remain on the filter in form of a moist red mass. This is boiled with alcohol slightly acidulated with sulphuric acid; the hæmatin is thereby dissolved, while the colourless globulin remains behind. Carbonate of ammonia is then added to the acid solution of hæmatin while it is yet hot, to remove sulphuric acid, and, after being cleared by filtration from sulphate of ammonia, and a little globulin which is precipitated, the liquor is evaporated to a twelfth of its bulk; it then deposits the hæmatin in form of a dark brown or almost black powder, from which a minute proportion of fat may be extracted by means of ether.

Hæmatin thus obtained appears to be altered by the process of separation, for it is no longer soluble in water. It is insoluble also in alcohol and ether; but it readily dissolves in any of these liquids after being mixed with potash, soda, or ammonia, forming deep red solutions. It likewise dissolves in alcohol to which an acid has been added, but its acid combinations are insoluble in water. When burned, it yields nearly ten per cent. of peroxide of iron, representing nearly seven per cent. of iron. The quantity of iron is estimated by Schmidt as 1 to 230 parts of red corpuscles. According to Mulder, hæmatin is composed of carbon 65·84, hydrogen 5·37, nitrogen 10·40, oxygen 11·75, and iron on 6·64; or C_{44}, H_{42}, N_3, O_6, Fe.

That hæmatin is an altered product is further shown by an observation of Hoppe, confirmed by Stokes, both of whom have found that the solution of cruor (obtained by diffusing the red clot in water) is speedily decomposed by acids, and that the coloured product of decomposition, which has all the characters of hæmatin, agrees with hæmatin in its effects on the prismatic spectrum, but differs in this respect from the natural or unaltered colouring matter of the cruor, which Mr. Stokes distinguishes by the name of *cruorin*.*

There has been much question as to the condition in which the iron exists in hæmatin, and especially whether it be in the state of oxide and in special combination with some part of the constituent oxygen, or associated in an elementary form with the organic matter, as sulphur is in albumen. The latter view seems to be the more probable, for the whole of the iron may be removed from hæmatin, without abstracting oxygen or disturbing the relative proportions of the other elements. When thus

* For an account of the examination of the colouring matter of the blood by the prism, and of the differences in its absorptive effect on light, according to its oxidated or deoxidated condition, the reader is referred to an important paper by Professor G. G. Stokes, in the Proceedings of the Royal Society for June 16, 1864, vol. xiii. p. 355.

deprived of iron the hæmatin retains its colour, and has suffered no appreciable change in character. It would seem therefore that iron, although a constant ingredient in the red corpuscle, is not an essential constituent of hæmatin, and it is, at any rate, clear that the red colour of the blood is not caused by iron.

Globulin.—When the hæmatin has been extracted from the blood-corpuscles by the foregoing method, the globulin and envelopes remain in combination or mixture with sulphuric acid. Globulin is a protein compound, agreeing very nearly with albumen and casein in elementary composition, so far as this has been ascertained, but most resembling the latter substance in its general characters. Globulin is nearly insoluble in pure water, but readily dissolves on a very slight addition of either an alkali or an acid. Weak acids throw it down from its solution in alkali, but when added in slight excess re-dissolve it. In like manner it is precipitated by alkalies from its solutions in acids and re-dissolved by excess. From neither of these solutions is it thrown down by heat. It is dissolved by neutral salts, and from this solution heat throws it down in an insoluble precipitate. From its slightly alkaline solution in water it is thrown down by a stream of carbonic acid, and may be re-dissolved by passing air or oxygen through the liquid. Its precipitate is distinguished from that of other albuminoids by being always in form of fine granules or molecules. But the most important and distinctive character of globulin is its fibrino-plastic property, to be afterwards further referred to, by which it co-operates with another protein-substance in producing solid fibrin; this property is destroyed by exposure of the solution to a boiling heat.

Globulin forms the greater part of the crystalline lens, and it is no doubt present in the pale blood-corpuscles; it exists also in the chyle and lymph, the cornea, the aqueous humour, and various other tissues and fluids, if its presence is to be inferred from the manifestation of the fibrino-plastic property. The globulin of the red corpuscles is crystallisable, as will be presently explained.

The *cruor*, or the soluble matter of the red corpuscles, which consists of the globulin and colouring principle (the cruorin of Stokes) together, forms in water a solution (maintained probably by soda and salts) which in its effects with re-agents agrees with solution of globulin. Berzelius reckons the relative proportions of globulin and hæmatin as 94·5 of the former, and 5·5 of the latter. Schmidt makes them 87·59, and 12·41 respectively. The corpuscles also contain a solid phosphuretted fat in small quantity, which may be stated at rather more than 2 parts in the 100 of dried corpuscles. 100 parts of dried cruor yield by calcination about 1·3 of brown alkaline ashes, which consist of carbonate of alkali with traces of phosphate 0·3, phosphate of lime 0·1, lime 0·2, subphosphate of iron 0·1, peroxide of iron 0·5, carbonic acid and loss 0·1.

Blood-crystals.—In the blood of man and various animals, when drawn from the vessels and set aside for a time, red crystals occasionally appear, consisting of globulin tinted by the colouring matter: and their formation may be promoted by adding water to defibrinated blood so as to set free the cruor from the corpuscles, and exposing the watered blood first to a stream of oxygen and then to carbonic acid. Or a drop of blood, defibrinated or not, is to be mixed with a little water on a slip of glass, exposed for a little to the air, then breathed upon, and finally covered with thin glass and placed in a bright light, which seems to favour the crystallisation. The

crystals are said readily to appear in both cases; but I must confess that the second method has generally failed in my hands with human or bullock's blood. The addition of alcohol, ether, and especially chloroform, greatly promotes the operation.

From human blood, and that of most mammals, the crystals are prismatic in form (fig. XIX.,[1]), but tetrahedral in the guineapig, rat, and mouse ([2]), hexagonal plates in the squirrel ([3]), and rhombohedrons in the hamster ([4]).*

Fig. XIX.

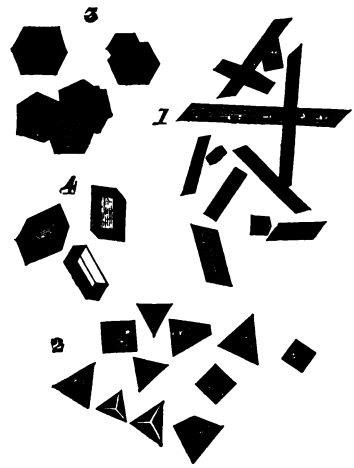


Fig. XIX.—Blood Crystals Magnified.

1, from human blood; 2, from the guineapig; 3, squirrel; 4, hamster.

The crystallising matter is perhaps modified in its properties under these different forms; at least, it has been found that all are not equally soluble in water. The red colouring principle (hæmatin) is not essential to the crystals, for Lehmann has, by recrystallisation, obtained them free from colour, and apparently unchanged in other respects; neither does the undissolved envelope or tegumentary frame of the corpuscle take any share in the crystallisation. The crystallising matter, therefore, must be the colourless protein-substance of the cruor, namely, globulin. It has been proposed to call this substance "blood-crystalline," on account of its property of crystallising, which does not belong to the globulin of the crystalline lens, so far as is yet known. The change of name, however, is confusing, and appears inexpedient, especially as we know that all forms of globulin agree in the much more characteristic property of being fibrino-plastic.

The hæmatin itself, or some chemical modification of it, can also, it is supposed, be crystallised; and the rhombic prisms and acicular crystals (*hæmin crystals*), obtained by Teichmann by treating blood with concentrated acetic acid, are considered to be of this nature. Crystals, moreover, of a substance (also occurring amorphously) which has been named "hæmatoidin," and is probably derived from modified hæmatin, are often found in old coagula and effusions of blood within the body. These occur in form of rhombic plates or prisms, of a yellow or red colour; they are insoluble in water, alcohol, ether, and acetic acid, and contain no iron.

Proportion of red Corpuscles.—The red corpuscles form by far the largest part of the organic matter in the blood: their proportion may be ascertained by filtering defibrinated blood mixed with solution of Glauber's salt, as already mentioned; or by weighing the dried clot, and making allowance for the fibrin it contains. The latter method, however, will serve only to give a rough estimate, as the very uncertain amount of serum remaining in the clot and affecting its weight cannot be determined. Prevost and Dumas made too large a deduction for the solid matter supposed to belong to the retained serum, and this reduced the estimate of

* A late writer, Bojanowski, represents them as rectangular tables in man and hexagonal plates in the mouse. Zeitsch. f. Wissensch. Zool. 1862.

the dried corpuscles too much, viz. to 129 parts per 1000 of blood. Lecanu also gives it at from 120 to 130. Becquerel and Rodier at from 131 to 152. Schmidt, from three modes of calculation, which it is needless here to explain, arrived at the conclusion that the proportion of *moist* red corpuscles in 1000 parts of blood is from 480 to 520; but there are reasons for regarding this as too high an estimate. He considers that in the moist state they consist of 31 per cent. of solid matter and 69 per cent. of water: on this understanding, of course, much of the water estimated by the loss in drying blood must be assigned to the corpuscles.*

Different observers agree that, as a general rule, the proportion of red particles is greater in the blood of the male sex than in that of the female. Lecanu gives the following mean result, derived from numerous analyses, exhibiting the proportion of dry crassamentum and water in the blood of the two sexes. No deduction is made for the fibrin; but, considering its small relative quantity, any possible variation in it cannot materially affect the general conclusion.

	Male.	*Female.*
Crassamentum, from	115·8 to 148	68·3 to 129·9
Water	778 to 805	790 to 853

Becquerel and Rodier state the crassamentum in the female at from 113 to 137.

Lecanu found the following differences in the crassamentum according to temperament:—

	Male.	*Female.*
Sanguine temperament	136·4	126·1
Lymphatic temperament	116·6	117·3

As regards age, Denis found the proportion of crassamentum greatest between the ages of 30 and 40. Sudden loss of blood rapidly diminishes it. In two women who had suffered from uterine hæmorrhage, the crassamentum amounted to only 70 parts in 1000. The same effect may be observed to follow ordinary venesection. In a person bled three times in one day, Lecanu found in the first drawn blood 139, and in the last only 76 parts of crassamentum in the 1000. This effect may be produced very suddenly after a bleeding. Prevost and Dumas bled a cat from the jugular vein, and found 116 parts of crassamentum in 1000, but in blood drawn five minutes afterwards, it was reduced to 93. The sudden loss of blood probably causes a rapid absorption of serous and watery fluid into the vessels, and thus diminishes the relative amount of the red particles. It is found that the blood of warm-blooded animals is richer in crassamentum than that of the cold-blooded; and, among the former, the proportion is highest in the class of birds.

Liquor Sanguinis.—The fluid part of the blood, as already described, separates spontaneously into fibrin and serum. The fibrin may be obtained by stirring the blood as soon as possible after it is drawn, or by washing the crassamentum with water, to free it from cruor. Procured in either of these ways, the fibrin contains pale corpuscles and a small portion of fat. From dried fibrin of healthy human blood, Nasse obtained near 5 per cent. of fat, and still more from the fibrin of buffy blood. The proportion of fibrin in the blood does not exceed $2\frac{1}{2}$ parts in 1000; indeed, according to the greater number of observers, it is not more than $2\frac{1}{5}$. As a general rule, the quantity is somewhat greater in arterial than in venous blood, and it is increased in certain states of the body, especially in inflammatory diseases and in pregnancy. Nasse thinks that the whole fibrin

* For an account of Schmidt's method, see Lehmann's Physiological Chemistry (Cavendish Society's Translation), vol. ii.

cannot be separated from the blood by the processes employed, for he believes that a portion remains suspended in the liquid in form of minute microscopic scales or films.

Denis pointed out, that fibrin obtained from the coagulum of venous blood, if quite recent, and not previously much exposed to the air, is capable of being slowly dissolved in a slightly-heated solution of nitre. Scherer and Nasse have confirmed this statement, and the latter finds that fibrin got by stirring may also be dissolved in the same way, provided it is quite fresh. On the other hand, nitre does not dissolve fibrin of arterial blood, nor fibrin that has been some time exposed to the air, from whatever source it may be derived; nor, according to Scherer, the fibrin of the buffy coat.

Origin of Fibrin.—It is now ascertained that the fibrin is not present, as such, in a liquid form, in the plasma, but is produced at the moment of consolidation by the co-operation or combination of two previously distinct substances. About twenty years ago, Professor Andrew Buchanan* discovered that the fluid of hydrocele, which might in an unmixed state be kept for an indefinite time without coagulating, very speedily congealed and separated into clot and serum when mixed with a little blood. Ordinary blood-serum, blood-clot, especially washed clot, and buffy coat, even after being dried and long kept, when added in small proportion to the hydrocele-fluid, produced the same effect. From these facts Dr. Buchanan concluded that fibrin exists as a liquid both in hydrocele-fluid and in the liquor sanguinis, that liquid fibrin does not coagulate spontaneously, but requires for that end the influence of some "suitable re-agents," that such a re-agent is naturally present in the blood, and brings about the solidification of its fibrin in the natural process of coagulation, and that it is absent from the hydrocele fluid, but when supplied by the addition of blood, causes the fluid fibrin to solidify. On further reasoning on the facts he had observed, Dr. Buchanan was led to believe that "coagulant power" was mainly seated in the pale corpuscles, which abound in the washed clot and the buffy coat, and are present in the serum; and that their efficacy depended on their organisation as elementary cells. In harmony with this latter view, he found on trial that the organised tissues, such as muscle, skin, and spinal marrow, possessed the same power, though in a less degree than the pale corpuscles, in which, as primary cells, the metabolic power is more energetic.

The remarkable phenomenon described by Dr. Buchanan did not obtain the consideration it deserved, and the coagulation of hydrocele-fluid under the conditions stated, was commonly ascribed to some catalytic action of the substance added, which induced liquid fibrin present in the fluid to solidify. In 1861, however, Dr. A. Schmidt, of Dorpat, apparently unaware of Dr. Buchanan's observations, fell upon facts of the same kind, and pursuing the investigation by an elaborate series of experiments not only with hydrocele-fluid, but with pericardial, peritoneal, and other serous fluids and effusions, which give a like result, has satisfactorily shown that fibrin has no existence in a liquid state, but that when it appears as a coagulum in a fluid, it is actually produced then and there by the union of two constituents present in solution, and forthwith shed out as a solid matter. One of these constituents which contributes in largest

* Proceedings of the Glasgow Philosophical Society, Feb. 19, 1845.

measure to the product, he names *fibrinogenous substance*, the other *fibrinoplastic substance*. In the coagulation of hydrocele-fluid, the former, or *fibrinogen*, is already there, while the *fibrinoplastin* is supplied from the blood. It is not that the latter converts albumen into fibrin, for after a certain amount of fibrin has been coagulated from the serous fluid no further addition will generate more, although abundance of albumen remains; and again, a given quantity of fibrinoplastin will not coagulate with equal rapidity and intensity any amount of fluid containing fibrinogen. In short, the fibrinoplastic substance seems not to operate as a ferment or by catalysis, but by combining with the other necessary ingredient. Now Schmidt has shown that the fibrinoplastic matter presents all the chemical characters of globulin, and is in fact nothing else than that substance. Accordingly he finds, as already stated, that blood-crystals are highly fibrinoplastic. This globulin is not restricted to the red corpuscles; it exudes from them into the plasma in the coagulation of the blood, and a residual portion remains in the serum when the process is over; globulin doubtless exists also in the pale corpuscles. Nor is it confined to the blood. From chyle and lymph, from the aqueous humour of the eye and watery extract of the cornea, from the vitreous humour and crystalline lens, from connective tissue, and from saliva and synovia, a substance may be obtained having the same re-actions and the same fibrinoplastic power. Fibrinogen may be thrown down from hydrocele-fluid by a mixture of alcohol and ether; it very closely resembles globulin in its chemical relations, only it is less soluble in acids and alkalies, and less energetic in all its re-actions. Of course, it exists in blood-plasma, and in the process of coagulation of the blood combines with globulin, transuded from the corpuscles, to form the fibrin of the clot.*

Serum.—This is a thin and usually transparent liquid, of a pale yellowish hue; it is, however, sometimes turbid, or milky, and this turbidity may depend upon different conditions, but most commonly on excess of fatty molecules. The specific gravity of serum ranges from 1025 to 1030, but is most commonly between 1027 and 1028 (Nasse), and is more constant than that of the blood. The solid contents of the serum are not more than 8 or 9 in 100 parts; the proportion of water being, for males 90·88, and for females 91·71. It is always more or less alkaline. When heated, it coagulates, in consequence of the large quantity of albumen it contains; and after separation of the albumen, a thin saline liquid remains, sometimes named "serosity." The following ingredients are found in the serum:—

Albumen.—This principle is considered to be combined with soda as an albuminate; its quantity may be determined by precipitating it in the solid form by means of heat or alcohol, washing with distilled water, drying, and weighing the mass. Its proportion is about 80 in 1000 of serum, or nearly 40 in 1000 of blood.

Globulin.—When serum is diluted with about ten times its bulk of distilled water, and subjected to a stream of carbonic acid, the liquid becomes turbid, and globulin is precipitated. It may also be obtained from the diluted serum by the cautious addition of acetic acid, but the least

* Schmidt, Alex., in Reichert & Du Bois Reymond's Archiv. für Anat. u. Physiol., 1861 and 1862. For a lucid account of the progress and present state of this question, founded on a confirmatory repetition of Buchanan's and of Schmidt's fundamental experiments, see an article on "the Coagulation of the Blood," [by Dr. Michael Foster,] in the Natural History Review for 1864, p. 157.

excess of acid will re-dissolve the precipitate. This globulin is probably the *casein* of the serum described by various authorities.

Fatty Compounds.—It has been already stated that the red corpuscles and the fibrin yield a certain quantity of fat ; but a portion of the fat of the blood remains in the serum, partly dissolved, and partly diffused in the liquid. It may be separated by gently agitating the serum with about a third of its bulk of ether, or by evaporating the serum and digesting the dry residue in ether, or in boiling alcohol. The turbid milky aspect which serum often exhibits, is in most cases due to a redundance of fat, and may accordingly be removed by agitation with ether.

The fatty matters of the blood are of various kinds, viz., *cholesterin, serolin,* and the ordinary saponifiable fats of the body (*margarates* and *oleates*) ; also, according to Berzelius and Lecanu, a *phosphuretted fat,* similar to that found in the brain. Berzelius, indeed, is disposed to think that the blood contains every variety of fat that is found in other parts of the body. Lecanu could not obtain the phosphuretted fat from either the serum or the fibrin, and Berzelius therefore supposes that it is associated with the red corpuscles; he also states that the fat extracted from the fibrin is different from ordinary fat. The usual quantity of fat of all kinds in 1000 parts of blood is stated by Lecanu to be 5·15, by Simon 2·3, and by Nasse 2·0.

Extractive Matters.—When the serum has been freed from albuminous matter by coagulation, and from fat by ether, and is evaporated to dryness, a yellowish or brown mass remains, consisting of organic matters mixed with salts ; the former belonging principally to the ill-defined class of substances denominated "extractive matters." These have now been more carefully sifted, and have yielded several definite and recognisable bodies, generated in the natural process of decomposition of the tissues, or residual matters of nutrition formed in the blood itself, and on their way to be excreted by the kidneys. Several of the substances to be next mentioned belong to this class, and as they are obviously excrementitial and transitory ingredients, they are not allowed to gather in any notable quantity in the healthy state of the economy.

Creatin and *Creatinin.*—Products of the natural "wear" of the muscles, or derived from fleshy food. These compounds, which are found in muscular substance and in the urine, together with *hypoxanthin* (also named *sarkin*), obtainable from the same sources, have been stated to exist in excessively small quantities in the blood.

Urea.—This substance, which accumulates in the blood of animals after extirpation of the kidneys or ligature of the renal arteries, as well as in certain diseases, has been found in very minute quantity in the healthy blood of the ox and of the calf, by Marchand and Simon, and in that of man, by Lehmann, Garrod, and others. It is, however, in such excessively small quantity, that its estimation is attended with great difficulty.

Uric Acid has been shown to exist in healthy blood by Dr. Garrod, and in that of persons suffering from gout it is in such considerable quantity as to be readily detected. In health its proportion is extremely small.

Hippuric Acid is found in the blood of herbivora, and according to some observers in that of man. There is, however, much doubt upon this point.

Leucin and *Tyrosin,* which exist in almost all secretions and excretions, probably are present in minute quantity in the blood ; but as yet they have only been detected in it in disease of the liver.

Sugar has been found in the blood of dogs, oxen, and cats, also in that

of diseased and healthy persons. The quantity is very small. The form of sugar is that known as glucose or grape sugar.

Colouring Principles.—A yellow or greenish-yellow colouring principle, supposed to be the same as that of the bile, has been found by various chemists in the blood of persons affected with jaundice, and, according to Lecanu and Denis, a certain amount of it may be detected even in healthy blood. The colouring matter which gives a pale yellowish tint to ordinary serum does not, however, exhibit the reactions of bile-pigments.

Odoriferous Matters. Denis describes three. 1. One combined with fat, smelling like garlick. 2. One supposed to depend on a volatile oil, with an odour said to be of peculiar character in each species of animal, and to be heightened by adding sulphuric acid to the blood. 3. One of a variable character, derived from the food. Schmidt found that the blood of only three animals yielded an odour distinctive of the species.

Salts.—1. Having soda and potash as bases, combined with lactic, carbonic, phosphoric, sulphuric, and fatty acids. Also chlorides of sodium and potassium, the former in large proportion. Schmidt has pointed out that the potash salts exist almost exclusively in the blood-corpuscles and the soda salts principally in the serum. In the corpuscles there are principally chloride of potassium and phosphate of potass: in the serum, chloride of sodium, and phosphate of soda. The following table (giving the mean of eight experiments) exhibits the relative quantities of potassium and sodium, and of phosphoric acid and chlorine, in the blood corpuscles and plasma.

100 parts of Inorganic Matters.

Blood-Corpuscles.		*Plasma.*		*Blood-Corpuscles.*		*Plasma.*	
K.	Na.	K.	Na.	PO_5.	Cl.	PO_5.	Cl.
40·89	9·71	5·19	37·74	17·64	21·00	6·08	40·68

The Table shows that the chlorides are, relatively to the phosphates, in much larger quantity in the plasma than in the blood-corpuscles; and that the phosphates are, relatively to the chlorides, in much larger proportion in the blood-corpuscles than in the plasma.

2. Lactate of ammonia. 3. Salts with earthy bases, viz., lime and magnesia with phosphoric, carbonic, and sulphuric acids.

The earthy salts are for the most part associated with the albumen, but partly with the crassamentum. As they are obtained by calcination, it has been suspected that the phosphoric and sulphuric acids may be in part formed by oxidation of the phosphorus and sulphur of the organic compounds. Nasse found in 1000 parts of blood 4 to 7 of alkaline, and 0·53 of earthy salts.

Mean Composition.—The following statement of the mean composition of human venous blood is from Lecanu. (Etudes chimiques sur le sang humain, Paris, 1837.)

Free oxygen, nitrogen, and carbonic acid				
Extractive matters				
Fatty matters, viz.				
Phosphuretted fat				
Cholesterin				
Serolin				
Oleic and margaric acids (free)				
Ditto combined with soda				
Volatile odoriferous oily acid (combined with a base).				
Salts, viz.			10·98	
Chloride of sodium				Serum . . 869·15
„ potassium				
„ ammonium				
Carbonate of soda				
„ lime				
„ magnesia				
Phosphate of soda				
„ lime				
„ magnesia				
Lactate of soda				
Yellow colouring matter				
Albumen			67·80	
Water			790·37	
Fibrin			2·95	
Hæmatin . .	2·27	Corpuscles 127·90		Crassamentum 130·85
Albumen (globulin)	125·63			
				1000·

Lecanu's statement refers all the water of the blood to the serum, and thus exaggerates the quantity of albumen. The following statement (from Lehmann) may be taken as a more correct account of the distribution of the several constituents; but the proportion assigned of albumen is probably somewhat too low.

In 1000 parts of Blood.

	Corpuscles.	*Plasma.*	*Total.*
Water	344	451·45	795·450
Hæmatin	8·375	...	8·375
Globulin and Envelopes .	141·110	...	141·110
Fat	1·155	0·860	2·015
Extractive matters . .	1·300	1·970	3·270
Saline „	4·060	4·275	8·335
Fibrin	...	2·025	2·025
Albumen	...	39·420	39·420
	500·	500·	1000·

Difference between Arterial and Venous Blood.—By arterial blood is meant that which is contained in the aorta and its branches (systemic arteries), the pulmonary veins and left cavities of the heart; the venous blood is that of the veins generally, the pulmonary arteries, and right cavities of the heart. Their differences, apart from their functional effects in the living body, come under the heads of colour and composition.

1. Colour. Arterial blood, as already stated, is scarlet, venous blood dark, or purple. Venous blood assumes the scarlet colour on exposure to air, *i. e.*, to oxygen. This change is greatly promoted by the saline matter of the serum, and may be accelerated by adding salts or sugar to blood, especially by carbonate of potash, or of soda, and by nitre. Salts added to dark blood, without exposure to oxygen or air, cause it to assume a red colour, but not equal in brightness to that of arterial blood. On

the other hand, the addition of a little water darkens the blood. According to Professor Stokes, the corpuscles in the former case "lose water by exosmosis, and become thereby highly refractive, in consequence of which a more copious reflexion takes place at the common surface of the corpuscles and surrounding fluid. In the latter case they gain water by endosmosis, which makes their refractive power more nearly equal to that of the fluid in which they are contained, and the reflexion is consequently diminished."* But the presence of serum or of saline matter is not indispensable to the brightening, for although the clot when washed free from serum scarcely if at all reddens on exposure to oxygen, yet it is found that the red matter when squeezed out of the clot and dissolved in water, still becomes brighter and clearer on exposure to oxygen, whilst the colour is darkened (and the solution becomes turbid from deposition of globulin), on being shaken with carbonic acid. As in this case the colouring matter is extracted from the corpuscles and is reddened by oxygen without the presence of salts, it is plain that the difference of colour of arterial and venous blood essentially depends, not on a difference in the figure or density of the corpuscles, but on an alteration produced in their colouring substance by oxidation and deoxidation, which alters its absorptive effect on the light.

2. Composition. The arterial blood, so far as is known, is uniform in nature throughout; but in passing through the capillary vessels into the veins, whilst it generally acquires the common characters of venous blood, it undergoes special changes in its passage through particular organs, so that the blood of all veins is not alike in quality. Thus the blood of the hepatic veins differs from that of the portal vein, and both are in various respects different from what might be regarded as the common venous blood, which is conveyed by the veins of the limbs, and of the muscular and cutaneous parts of the body generally. Moreover, Bernard has shown that the blood of veins returning from secreting glands differs according to the state of functional activity of the organs. Whilst their function is in abeyance the blood in their veins is dark, as usual, but when secretion is active, the blood, which then also flows much more freely and abundantly, comes through from the arteries to the veins with very little, if any, reduction of its arterial brightness; it also retains nearly the whole of its separable oxygen.

Compared with blood from a cutaneous vein, arterial blood is found to contain a very little more water (about five parts in 1000), and to have a somewhat lower specific gravity. The arterial plasma yields more fibrin and coagulates more quickly; the serum is said by Lehmann to contain less albumen and less fat, but more extractive and a little more saline matter. According to the same authority, the corpuscles also contain less fat, but relatively more hæmatin and salts. Arterial blood yields more oxygen gas, and less of, both free and combined, carbonic acid.

Blood of the portal vein, compared with that of the jugular vein, is stated by Lehmann to contain more water in proportion to solid matter, less fibrin and albumen, more fat, extractive matter and salts. Its corpuscles are said to be richer in hæmatin.

In the blood of the splenic vein, as compared with that of the corresponding artery, according to the observations of Funke, the red corpuscles are smaller, more spheroidal in form, and more resistant to the destructive effects of water; and when they run together it is in rounded heaps, not in regular piles. Their cruor has a marked tendency to form crystals. The pale corpuscles are vastly more numerous than in the arterial blood, and some of them have a yellowish tint (as if in transition to red disks). *Granule-cells* occur occasionally and sparingly, twice as large as the pale corpuscles, but otherwise resembling them. The plasma is distinguished by its poverty in fibrin.

The blood of the hepatic veins shows, according to Lehmann's statement, the following differences from that of the portal vein. It is richer in both red and pale corpuscles, possibly from loss of water. The red corpuscles present the same peculiarities of size, form, resistance to water, and mode of aggregation, as in the splenic venous blood. They contain less fat and salts than in portal blood, less hæmatin, at least less iron, but somewhat more extractive matter; the proportion of pale corpuscles to the red is increased. The plasma is more concentrated, but is deficient in

* Proc. Royal Soc., vol. xiii. p. 362.

fibrin (or spontaneously coagulating matter), and does not form a true clot. The serum contains less albumen and fat, and much less saline, but more extractive matter. The hepatic venous blood, moreover, yields sugar, derived from glycogen, formed in the liver.

The blood of the *renal veins* is said by Bernard and Brown Séquard not to coagulate in the normal state of the kidney and its function, from which they infer that it contains little or no fibrin; but it may be that there is something present which prevents the two constituents of the fibrin from reacting on each other.

COAGULATION OF THE BLOOD.

In explaining the constitution of the plasma, we have been obliged so far to anticipate the account of the coagulation of the blood. The following are the phenomena which usher in and which accompany this remarkable change. Immediately after it is drawn, the blood emits a sort of exhalation, the "halitus" having a faint smell; in about three or four minutes a film appears on the surface, quickly spreading from the circumference to the middle; a minute or two later the part of the blood in contact with the inside of the vessel becomes solid, then speedily the whole mass; so that, in about eight or nine minutes after being drawn, the blood is completely gelatinised. At about fifteen or twenty minutes, or it may be much later, the jelly-like mass begins to shrink away from the sides of the vessel, and the serum to exude from it. The clot continues to contract, and the serum to escape for several hours, the rapidity and degree of the contraction varying exceedingly in different cases; and, if the serum be poured off, more will usually continue to drain slowly from the clot for two or three days.

The nature of the change which takes place in the coagulation of the blood has been already spoken of; it is essentially owing to the coagulation of the liquor sanguinis, the fibrin being generated in that liquid by the concurrence of its two constituents in the way already explained, and separating in form of a solid mass, which involves the corpuscles but allows the serum to escape from it in greater or less quantity. But although the solidification of the fibrin and formation of a red clot would undoubtedly take place independently of any mechanical co-operation on the part of the corpuscles, still it must not be forgotten that the red disks are not altogether indifferent while coagulation goes on; for they run together into rolls, as already described, and the circumstance of their doing so with greater or with less promptitude materially affects the result of the coagulating process. Thus there seems good reason to believe that, as H. Nasse has pointed out, one of the causes—and in inflammatory blood probably the chief cause—of the production of the buffy coat, is an exaltation of the natural tendency of the red disks to run together, whereby being more promptly and more closely aggregated into compact masses, they more speedily subside through the liquid plasma, leaving the upper part of it colourless by the time coagulation sets in; and Mr. Jones has drawn attention to another influential circumstance depending likewise on the corpuscles, in inflammatory blood, namely, the more rapid and close contraction of the network, or spongework as he terms it, into which the little rolls of corpuscles unite, and the consequent expulsion of the great part of the liquor sanguinis from its meshes before the fibrin solidifies, in which case the mass of aggregated corpuscles naturally tends to the lower part of the vessel, whilst the expressed plasma, being lighter, accumulates at the top. Of course it is not meant to deny that more tardy coagulation of the plasma would produce the same result as more

speedy aggregation of the corpuscles; it is well know, indeed, that blood may be made to show a buffy coat by delaying its coagulation, but buffed inflammatory blood is not necessarily slow in coagulating.

Circumstances affecting Coagulation.—Various causes accelerate, retard, or entirely prevent the coagulation of the blood; of these it will here suffice to indicate the more important and best ascertained.

1. Temperature.—Cold delays, and at or below 40 degrees Fahr. wholly suspends, coagulation; but even frozen blood, when thawed and heated again, will coagulate. Moderate elevation of temperature above that of the body promotes coagulation.

2. Coagulation is accelerated by contact of the blood with foreign matter, such as the sides of the basin or other vessel into which it is drawn. On the other hand, the maintenance of its fluidity is favoured by retention within its vessels or natural receptacles where it is in contact with the natural tissues of the body; but when the coats of the vessels or other tissues, with which the blood is contiguous, lose their vitality and are altered in their properties, they become as foreign bodies, and coagulation is promoted. The usual exposure of drawn blood to the air promotes coagulation, but according to Lister, by no means so powerfully as has been heretofore generally understood. The effect of other gases is the same. Coagulation speedily takes place when blood is subjected to the air-pump, and has therefore been said to occur readily in vacuo, but Lister finds that this is owing to the agitation caused by the bubbling of the blood from the escape of liberated gas, whereby more and more of it is successively brought into contact with the sides of the vessel.

3. Arrest of the blood's motion *within the body* favours coagulation, probably by arresting those perpetual changes of material, both destructive and renovative, to which it is naturally subject in its rapid course through the system. The coagulation of the stagnant blood after death is also largely to be ascribed to the alteration then ensuing in the coats of the containing vessels. Lister found that, after death, blood remains longer fluid in the small veins than in the heart and great vessels; and even in these the coagulation is usually slow. Agitation of *exposed* blood accelerates coagulation by increasing its exposure to foreign contact.

4. Water, in a proportion not exceeding twice the bulk of the blood, hastens coagulation; a larger quantity retards it. Blood also coagulates more speedily when the serum is of low specific gravity, indicative of much water in proportion to the saline ingredients.

5. Almost every substance that has been tried, except the caustic alkalies, when added to the blood *in minute proportion*, hastens its coagulation; although many of the same substances, when mixed with it in somewhat larger quantity, have an opposite effect. The salts of the alkalies and earths, added in the proportion of two or three per cent. and upwards, retard, and, when above a certain quantity, suspend or prevent coagulation; but, though the process be thus suspended, it speedily ensues on diluting the mixture with water. Caustic potash and soda permanently destroy the coagulability of the blood. Acids delay or prevent coagulation. Opium, extract of belladonna, and many other medicinal agents from the vegetable kingdom, are said to have a similar effect when mixed with the blood; but the statements of experimenters by no means entirely agree respecting them.

6. Certain states of the system.—Faintness occasioned by loss of blood favours coagulation; states of excitement are said to have, though not

invariably, the opposite effect. Impeded aëration of the blood in disease, or in suffocative modes of death, makes it slow to coagulate; probably from retention of carbonic acid. In cold-blooded animals, with slow circulation and low respiration, the blood coagulates less rapidly than in the warm-blooded; and, among the latter, the tendency of the blood to coagulate is strongest in birds, which have the greatest amount of respiration, and highest temperature.

7. Coagulation commences earlier, and is sooner completed, in arterial than in venous blood. Dr. Nasse finds that women's blood begins to coagulate nearly two minutes sooner than that of the male sex.

In general, when blood coagulates quickly, the clot is more bulky and less firm, and the serum is less effectually expressed from it; so that causes which affect the rapidity of coagulation will also occasion differences in the proportion of the moist clot to the exuded serum.

There is no sufficient evidence of evolution of heat or of disengagement of carbonic acid from blood during its coagulation, which some have supposed to occur.

Theory of Coagulation.—Although it is certain that the coagulation of the blood consists in solidification of fibrin, and although it seems tolerably well established that this is the result of the combination of two primarily separate animal principles, it is by no means clearly understood how such combination and solidification do not naturally take place within the living body, and how the several conditions already mentioned as influencing the process operate in promoting or opposing coagulation.

According to the explanation proposed a few years ago by Dr. B. W. Richardson,* the blood is kept liquid within the vessels by ammonia, which maintains the fibrin in solution (or, as it may be now expressed, hinders the union of fibrinogen and globulin), and drawn blood coagulates in consequence of the loss of ammonia which escapes from it on exposure. Drawn blood placed in an atmosphere of ammonia remains fluid; and, according to Dr. Richardson, the natural presence of ammonia in blood may be demonstrated, as well as its extrication from blood on exposure to air or in a vacuum. The more extensive and thorough the exposure, the more speedy is the escape of ammonia, and the quicker is the coagulation. Heat hastens coagulation by hastening the extrication of ammonia, whilst, by retaining it, cold delays or suspends the change. Moreover Dr. R. found that air which had become charged with the volatile element by passing through one portion of blood delayed the coagulation of another portion through which it was sent.

Nothing could at first sight appear more natural and consistent than this explanation; but of the facts on which it mainly rests, some have since been disputed, and others differently interpreted. Thus after a most elaborate research, a late inquirer (Thiry) has been unable to find evidence of free ammonia in fresh blood. Again, Lister finds that blood may be poured from one piece of a vein into another, in a small stream through the air several times, so as to give ample opportunity for the escape of ammonia, and yet remain fluid for hours after. Lastly, the different effects of heat and cold may be ascribed to their influence in promoting or hindering the mutual reaction of the two constituents of the fibrin.

According to another view, which is fundamentally the same as that entertained by John Hunter and some other British physiologists, and which has recently been advocated by Professor Brücke of Vienna,† the blood has a natural tendency to coagulate; or, if we may use the language suggested by later researches, the globulin and fibrinogen naturally tend to combine; within the body this tendency is held in check by some inhibitory or restraining influence exercised by the coats of the vessels and the living tissues in contact with the blood; but when blood is withdrawn from its natural receptacles, or if these lose their vitality, its intrinsic disposition to

* The Cause of the Coagulation of the Blood. 1857.

† British and Foreign Medico-Chirurgical Review, vol. xix. 1857.

coagulate being no longer opposed, is allowed to prevail. At the same time it is not inconsistent with this theory to admit the positive efficacy of contact with foreign or dead matter in promoting coagulation. Mr. Lister,* on the other hand, considers that the blood has no spontaneous tendency to coagulate, either within or without the vessels, but that the coagulation is brought about in drawn blood by contact with foreign matter. Accepting the conclusion of Schmidt, that globulin and fibrinogen are necessary to the evolution of fibrin, he thinks that if these bodies unite in ordinary chemical combination, the action of foreign matter may determine their union, as spongy platinum promotes the combination of oxygen and hydrogen. He considers that the living vessels do not exert any action to prevent coagulation, but that their peculiarity, as distinguished from an ordinary solid, consists in the remarkable circumstance that their lining membrane, in a state of health, is wholly negative in its relation to coagulation, and does not cause that molecular disturbance, so to speak, which is produced in the blood by all ordinary matter. When the vessels lose their peculiar property by death, or become seriously altered by disease or injury, their contact with the blood induces coagulation like that of an extraneous body. Finally, it may be observed, that in any attempted explanation of the coagulation of the blood, it is well to bear in mind that there is a purely physical or chemical phenomenon, which, as suggested by Mr. Graham, has a certain analogy to it, namely, the change from the liquid to the insoluble state so easily induced in colloidal matter by slight external causes.

THE LYMPH AND CHYLE.

A transparent and nearly colourless fluid, named "lymph," is conveyed into the blood by a set of vessels distinct from those of the sanguiferous system. These vessels, which are named "lymphatics," from the nature of their contents, and "absorbents," on account of their reputed office, take their rise in nearly all parts of the body, and, after a longer or shorter course, discharge themselves into the great veins of the neck; the greater number of them previously joining into a main trunk, named the thoracic duct,—a long narrow vessel which rises up in front of the vertebræ, and opens into the veins on the left side of the neck, at the angle of union of the subclavian and internal jugular; whilst the remaining lymphatics terminate in the corresponding veins of the right side. The absorbents of the small intestine carry an opaque white liquid, named "chyle," which they absorb from the food as it passes along the alimentary canal; and, on account of the milky aspect of their contents, they have been called the "lacteal vessels." But in thus distinguishing these vessels by name, it must be remembered, that they differ from the rest of the absorbents only in the nature of the matters which they convey; and that this difference holds good only while digestion is going on; for at other times the lacteals contain a clear fluid, not to be distinguished from lymph. The lacteals enter the commencement of the thoracic duct, and the chyle, mingling with the lymph derived from the lower part of the body, is conveyed along that canal into the blood.

Glands.—Both lacteals and lymphatics, in proceeding to their destination, pass into and out of certain small, solid, and vascular bodies, named lymphatic glands, which have a special structure and internal arrangement, as will be afterwards described; so that both the chyle and lymph are sent through these glands before being mixed with the blood.

This much having been explained to render intelligible what follows, we

* On the Coagulation of the Blood; the Croonian Lecture for 1863,—Proceedings of the Royal Society, vol. xii. p. 580.

may now consider the lymph and the chyle, which, as will be seen, are intimately related to the blood.

LYMPH.

The lymph may be procured free from admixture of chyle, and in quantity sufficient for examination, from the larger lymphatic vessels of the horse or ass. It may also be obtained by opening the thoracic duct of an animal that has fasted for some time before being killed. It is a thin fluid, transparent and colourless, or occasionally of a pale yellow hue; its taste is saline, its smell faint and scarcely perceptible, and its reaction alkaline. Sometimes the lymph has a decided red tint, of greater or less depth, which becomes brighter on exposure to the air. This redness is due to the presence of coloured corpuscles, like those of the blood: and it has been sometimes supposed, that such corpuscles exist naturally in the lymph, in greater or less quantity; but they are more probably introduced into the lymphatic vessels accidentally. It can, in fact, be shown that when an incision is made into a part, the blood very readily enters the lymphatics which are laid open, and passes along into larger trunks; and in this way blood is conveyed into the thoracic duct, or any other large vessel, exposed as usual by incision immediately after the animal is killed. Indeed, mere rough handling of some organs, such as the liver and spleen, will rupture the fine vessels and cause the contents of the issuing lymphatics speedily to become red from admixture of blood.

The lymph, when examined with the microscope, is seen to consist of a clear liquid, with corpuscles floating in it. These "lymph corpuscles," or lymph globules, agree entirely in their characters with the pale corpuscles of the blood, which have been already described (page xxxi.). It is alleged that some of the lymph corpuscles have a yellowish tint. Occasionally, smaller particles are found in the lymph; also, but more rarely, a few oil globules of various sizes, as well as red blood-corpuscles, the presence of which has just been referred to.

The liquid part (lymph-plasma) bears a strong resemblance in its physical and chemical constitution to the plasma of the blood; and accordingly, lymph fresh-drawn from the vessels coagulates after a few minutes' exposure, and separates after a time into clot and serum. This change is owing to the combination of the constituents of the fibrin contained in the lymph-plasma, and in this process most of the corpuscles are entangled in the coagulum. The serum, like the corresponding part of the blood, consists of water, albumen, extractive matters, fatty matters in very sparing quantity, and salts. Sugar exists in small quantity in the lymph, and urea, in the proportion of from 0·01 to 0·02 per cent.; leucin has also been found, at least in the lymphatic glands.

Human lymph has been obtained fresh from the living body in several instances, from lymphatic vessels opened by wounds or other causes. It has been found to agree in all material points with the lymph of quadrupeds.

CHYLE.

The chyle of man and mammiferous animals is an opaque, white fluid, like milk, with a faint odour and saltish taste, slightly alkaline or altogether neutral in its reaction. It has often a decided red tint, especially when taken from the thoracic duct. This colour, which is heightened by

DIVISION I.

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SYSTEMATIC OR DESCRIPTIVE ANATOMY.

Systematic or Descriptive Anatomy embraces the consideration of the organs of the body in an order arranged according to their nature and connections. It is called Systematic in opposition to Topographic or Demonstrative Anatomy, in which the various dissimilar organs found in each region are described together, and which is particularly adapted for the study of the relative position of parts.

The organs and parts of the body may be regarded from two distinct points of view, the Physiological and the Morphological.

Viewed in their physiological aspect, they form a series of instruments fitted for the accomplishment of particular purposes. Thus, for example, the bones form levers, which are moved by the muscles; and the combinations of these in the hand are fitted for grasping, while those of the foot are adapted for walking.

But considered apart from the functions of its organs, the human body, as well as all other organisms, exhibits a regular plan in its construction, to investigate the nature of which is the object of Morphological Anatomy. That plan cannot be competently examined except with the aids furnished by the study of Development and Comparative Anatomy. One of the most general facts connected with the plan of construction of the human body is its segmented nature, similar sets of parts being placed in succession, so that the line of their series forms the long axis of the body, and parts found in one segment or member of the series correspond, often very distinctly, to parts in other segments.

The segmented plan is that on which are constructed not only vertebrate animals, or all those which are possessed of a vertebral column, but also the higher invertebrate classes. It is most manifestly displayed in the class *articulata*, in some of which nearly the whole body is composed of a chain of precisely similar segments; while in others the segments are fused together in groups, so as to form more complicated structures. In the human body the appearance of segmentation is seen most conspicuously in the osseous system; it likewise pervades the nervous system, and is observable in some other structures. The trunk of the body is formed by a series of segments, indistinguishably blended together in some of the systems, but distinct in others; while the limbs are rather to be regarded as lateral outgrowths connected with a certain number of segments. Such segments of the body may be named *vertebral segments*, or, as Goodsir has suggested, *somatomes;* and to distinguish sections of the skeleton, the nervous, muscular, or other systems, the terms *sclerotome, neurotome, myotome*, &c., proposed by the same author, may sometimes be conveniently employed.

Correspondence of structural elements in different animals, or in different segments of the same animal, constitutes what is now generally called *homology*. Thus the wings of birds and the forelimbs of quadrupeds are homologous with the upper limbs of man, and vertebræ are homologous one with another. To distinguish the correspondence of parts which lie in series from that which exists between structures in different animals, Owen has suggested for the former the term *homotypy*, and the phrase *serial homology* is likewise employed. Thus the bones of the foot are serially homologous, or homotypic, with those of the hand.

To express resemblance of a general nature, arising from similarity of function, the term *analogy* has been adopted by recent authors. While structures fundamentally similar are regarded as homologous, although the progress of their development and the purposes for which they are adapted may be different, organs adapted for similar purposes are said to be analogous, however different in their original anatomical relations may be the parts of which they are composed. Thus the gills, being the respiratory organs of fishes, are analogous to the lungs of the air-breathing vertebrata; but they are not homologous parts.

Descriptive Terms.—As it is the office of descriptive anatomy to indicate with precision not only the form and structure, but also the position in relation to other parts of objects which are often irregular and complicated, it is important that it should have a generally recognised system of nomenclature: hence many words expressive of relative position, have acquired a restricted technical sense in which they are generally used by anatomists. It may be proper to mention here the most important of those terms. The *mesial plane* is that in which the body might be divided into a right and left lateral half; the *middle line* being the line before and behind, in which that plane meets the surface of the body. *Internal* and *external* denote relative nearness to and distance from the mesial plane towards either side. *Superficial* and *deep* indicate distance from the surface; and in the expression of this relation it is well to avoid the use of the terms *external* and *internal*, *inner* and *outer*, *above* and *below*, or to employ them with the utmost caution, lest they become a source of confusion. Nevertheless, an exception to this rule is still very generally made in the instances of some phrases which have been long in use. Thus the superficial and deep oblique muscles of the abdomen are commonly called external and internal, and so also with the superficial and deep inguinal rings. *Superior*, *inferior*, *above*, *below*, *anterior*, and *posterior* have reference to the position of parts in the erect posture of the body. As, however, the employment of those terms, though unobjectionable in human anatomy, is liable to give rise to ambiguity in general or comparative descriptions of structure in man and animals, it is frequently preferable to substitute others which express position by reference to a region or structure towards which the part is directed. Thus *ventral* and *dorsal* may be often employed instead of anterior and posterior, and, in the limbs, *proximal* and *distal* instead of superior and inferior. The inferior aspect of the lung may be called diaphragmatic, the posterior aspect of the gullet vertebral, and so on.

Section I.—OSTEOLOGY.

The osseous system forms the *skeleton* or solid framework of the body. It supports the soft parts, protects delicate organs, and furnishes places of attachment to the muscles, by which the different movements are executed. The osseous parts of the skeleton are bound together by ligaments; and in some parts the framework is completed by the addition of cartilages. A *natural skeleton* is one in which the connecting parts have been preserved; while, in an *artificial skeleton*, the ligaments and cartilages having been removed by complete maceration, the bones are united by artificial mechanical contrivances, and the cartilages are replaced by some other substance.

The number of bones in the skeleton varies at different ages of life, some which are originally distinct becoming united together as the process of

ossification proceeds. The following is an enumeration of those usually reckoned as distinct in middle life :—

	Single Bones.	Pairs of Bones.	Total.
The spinal column consists of twenty-four free vertebræ, the sacrum, and the coccyx	26		26
The skull consists of twenty-two bones: of these eight are cranial, viz., four single bones, the occipital, frontal, ethmoid and sphenoid; and two pairs, the parietal and temporal. Fourteen are facial, viz., two single bones, the vomer and inferior maxillary bone; and six pairs, the nasal, lacrymal, superior maxillary, malar, palatal, and turbinated	6	8	22
There are twelve pairs of ribs, a sternum, and a hyoid bone	2	12	26
The superior extremities consist each of a clavicle and scapula, humerus, radius, ulna, eight carpal bones, five metacarpal, and fourteen digital		32	64
The inferior extremities consist each of a pelvic bone, femur, patella, tibia, fibula, seven tarsal bones, five metatarsal, and fourteen digital		31	62
	34	83	200

Besides the bones above enumerated, there exist, likewise, three pairs of auditory ossicles, and, in addition to the patella, various smaller bones called sesamoid. The auditory ossicles, though enclosed within the temporal bones, may be considered as belonging to the skeleton. The sesamoid bones are only accessories to the tendons in which they are developed.

Fig. 1.

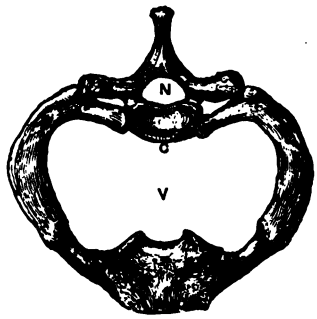


Fig. 1.—First Dorsal Vertebra, First Rib and Cartilage, and Upper Part of the Sternum, seen from above, giving a view of a Segment of the Vertebrate Skeleton. ½
C, body or centre; N, vertebral ring or neural arch; V, cavity of the chest enclosed by the ribs or visceral arch.

The segments of the skeleton are so disposed as to surround or partially enclose two cavities of unequal size—the neural and visceral. The neural cavity, comprehending the cranium and vertebral canal, is of great width in the head, and comparatively small in the rest of its length: it is nearly completely bounded by bony walls in its whole extent. The visceral cavity, placed in front of the vertebral column throughout its length, is only imperfectly represented in the head by spaces enclosed by the bones of the face: its walls, which are very incomplete, are most perfect in the thorax and pelvis, and leave large open spaces in the regions of the neck and abdomen. In these several regions, the relative position of the walls of the neural and visceral cavities and of their contained viscera remains the same.

1.—THE VERTEBRAL COLUMN.

The vertebral column may be considered as the foundation of the whole skeleton, not only because it exists in all animals which possess an osseous system, but because it is the centre round which the other parts are developed

and arranged. Superiorly, it supports the skull; laterally, the ribs are attached to it, through which it receives the weight of the upper limbs; and near its inferior extremity it rests upon the pelvic bones, which communicate the weight of the body to the lower limbs. Besides being a pillar of support to the rest of the skeleton, it furnishes protection to the spinal cord by enclosing it in an osseous canal. It is composed of a series of bones, called vertebræ, the most of which are united together by joints and elastic substance, and a few by bony connection, in such a manner that, although the amount of motion allowed between each pair is slight, the aggregate of that in the whole is sufficient to give the column very considerable flexibility.

The twenty-four upper vertebræ remain separate in the adult, and retain their mobility: they increase in size from above downwards. They are succeeded by five others, which rapidly diminish in size from above downwards, and which are united into one mass, called the *sacrum;* beyond the sacrum are four dwindled terminal members of the series, which as age advances become likewise united, and form the *coccyx.* Thus the column may be said to consist of two irregular pyramids, the common base of which is at the superior extremity of the sacrum.

THE MOVEABLE VERTEBRÆ.

GENERAL CHARACTERS.

The general characters of the vertebræ are best exhibited in those which are placed near the middle of the column. Those at the extremities present a greater number of distinctive peculiarities. The following description is applicable to the great majority of moveable vertebræ.

Each vertebra has more or less the form of a ring, and presents for consideration a body, arch, and processes.

The *body,* the large mass in the anterior part of the vertebra, is a short cylinder, which, when united by elastic intervertebral plates with the others of the series, contributes to form a firm but flexible pillar of support. Anteriorly, it is rounded forwards, and slightly hollowed from above downwards. Posteriorly, it forms part of the ring, and is slightly hollowed from side to side. Its superior and inferior surfaces are nearly flat, excepting in the cervical region, and give attachment to the intervertebral plates. The vertical surfaces are pierced by numerous foramina for blood-vessels, principally veins: one or more of these, situated near the middle of the posterior surface exceeds the other greatly in size.

The *arch* consists of two symmetrical halves which spring from the body, towards its back part, and meet in the middle line behind. The anterior part of each lateral half, rounded and narrow, is called the *pedicle;* the posterior part is broad and flat, and is called the *lamina* or *plate.*

The *spinous process* or *spine* projects backwards from the arch in the middle line. The appearance presented by the linear series of spinous processes has led to the application of the name spine to the whole column. The *transverse processes,* placed one at each side, project outwards from the arch. The *articulating processes,* two superior and two inferior, project upwards and downwards from the laminæ. They are furnished with articular surfaces, coated with cartilage, which in the superior processes look backwards, and in the inferior look forwards, so that the former face the latter in adjoining vertebræ.

The concavities on the upper and lower borders of the pedicles are named *notches,* and constitute by the apposition of those of contiguous vertebræ the

intervertebral foramina, a series of rounded apertures which communicate with the vertebral canal, and transmit the spinal nerves and blood-vessels.

The *foramen*, enclosed by the vertebral *ring*, is bounded anteriorly by the body, and posteriorly and laterally by the arch. The series of rings united by ligaments constitutes the *vertebral canal*, in which the spinal cord is contained.

Texture.—The bodies of the vertebræ are almost entirely composed of spongy substance, the surface being covered with only a thin layer of compact tissue. Venous canals, commencing at the larger foramina behind, traverse the cancellated structure. The arch and processes contain a much smaller proportion of spongy substance, being covered with compact tissue of considerable density in some places.

CHARACTERS PECULIAR TO GROUPS OF VERTEBRÆ.

The moveable vertebræ are divided into three groups, named from the regions which they occupy, *cervical*, *dorsal*, and *lumbar*.

Each of those groups is marked by distinctive characters. The central vertebræ of each group differ so much in all their parts from those of other groups, that any portion, such as the body, ring, or one of the processes, is alone sufficient to indicate to which they belong. On the other hand, the vertebræ at the extremities of each group are assimilated in their characters to those of the neighbouring group.

In the following description the characteristics of each group, as existing in its central members, will first be given, and then the slighter differences of other members will be stated.

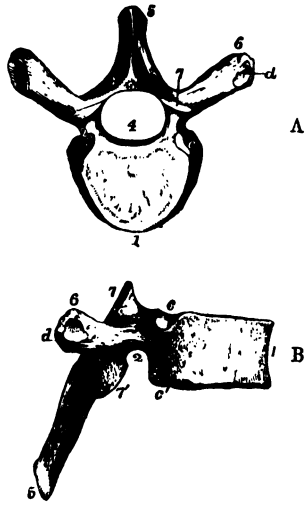
DORSAL VERTEBRÆ.

The dorsal vertebræ, twelve in number, support the ribs. They are the simplest in form, and ought to be the first to engage the attention of the student. Their position is between the cervical and lumbar groups, and they are also of intermediate size.

Fig. 2.—The Sixth Dorsal Vertebra. ½

A, viewed from above; B, viewed from the right side. 1, the body; 2, the pedicle; 3, the lamina; 4, vertebral ring, nearly circular; 5, spinous process; 6, transverse process; 7, 7′, superior and inferior articulating processes; *c*, *c*′, superior and inferior facets on the body for the articulation of the head of the rib; *d*, facet on the transverse process for the articulation of the tubercle of the rib.

Fig. 2.



The *body* is somewhat narrower in front than behind: its antero-posterior and transverse diameters are nearly equal, and it is somewhat heart-shaped, as seen from above or below. It is specially characterized by the presence, at the place where it joins the arch, of depressed articular surfaces for the heads of ribs. In the greater number of instances, there are two costal surfaces on each side,—one on the superior, the other on the inferior border,—so placed that each completes with that of the adjacent vertebra a cavity for the head of one

rib. The body of the first dorsal vertebra is, however, distinguished by having on each side a complete articular surface for the head of the first rib, besides a smaller surface on the lower border for one facet of the second rib: the costal surface on the tenth vertebra is usually complete for the tenth rib; and on the eleventh and twelfth there is only one articular surface on each side for the corresponding ribs.

The *laminæ*, shorter and deeper than in the cervical vertebræ, are imbricated or sloped one pair over another like tiles on a roof. The *pedicles* are nearly on a level superiorly with the upper surface of the body; and hence the superior notches are very shallow, while the inferior notches are comparatively deep.

The *spinous process*, described as bayonet-shaped, is three-sided, elongated, and sloped, and terminates in a slight tubercle. It is longest and has the greatest downward inclination in those towards the centre of the series; and in them the terminal tubercles are slender, while those of the upper and lower vertebræ are thickened.

The *transverse processes* are directed outwards and backwards, and present in front of the extremity, which is enlarged into a rough tubercle, a small surface for articulation with the tubercle of the rib. There is, however, no such surface in the case of the eleventh or twelfth dorsal vertebræ. In several of the lowest dorsal vertebræ there may readily be recognized on the extremity of the transverse process, when looked at from behind, three tubercular elevations, varying somewhat in form and size, and which are named the external, internal, and inferior tubercles of the transverse process. In the twelfth vertebra, in which the transverse process is extremely short, those three tubercles are most fully developed. They correspond respectively to the transverse, mammillary, and accessory tubercles afterwards noticed in the lumbar vertebræ. (See Fig. 4, *e*, *f*, 6.)

The *articulating processes* have their cartilaginous surfaces nearly vertical. Those of the superior processes look backwards and slightly upwards and outwards, those of the inferior processes look forwards and slightly downwards and inwards. But the superior articular processes of the first dorsal vertebra are similar to those of the cervical, and the inferior of the twelfth dorsal to those of the lumbar vertebræ.

The *ring* is nearly circular, and is smaller than in the cervical or lumbar region.

LUMBAR VERTEBRÆ.

The lumbar vertebræ are five in number. They are distinguished by their great size and the absence of costal articulating surfaces.

The *body* has a greater diameter transversely than from before backwards, and viewed from above or below its surface presents a reniform outline. That of the fifth lumbar vertebra has the distinctive character of being considerably deeper at its anterior than at its posterior margin.

The *laminæ* are shorter, deeper, and thicker than those of the dorsal vertebræ. The superior *notches* are shallow, the inferior deep, as in the dorsal vertebræ.

The *spinous process*, projecting horizontally backwards, is shaped like the blade of an axe, but is thickened and rough along the edge which forms its extremity.

The *transverse processes*, long and compressed, with a superior and inferior thin margin, project directly outwards. Their extremities lie in series with the external tubercles of the lower dorsal transverse processes and

with the ribs. Behind each, at its base, is a small process pointing downwards, which corresponds with the inferior tubercles of the dorsal transverse processes, and is also called the *accessory* process. The transverse processes of the fifth lumbar vertebra are shorter and thicker than those above, and are usually slanted a little upwards.

Fig. 3.

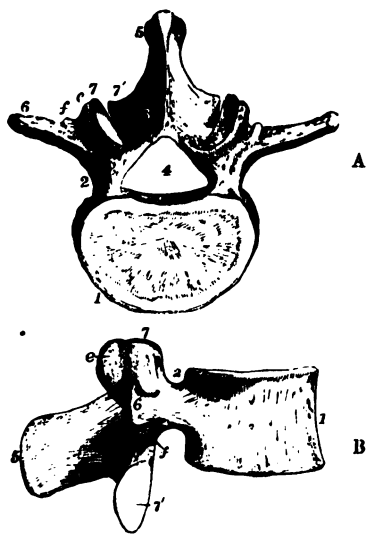


Fig. 3.—Third Lumbar Vertebra. ½

A, from above; B, from the right side. 1, the body; 2, the pedicle and intervertebral notch; 3, the lamina; 4, the vertebral ring, somewhat triangular; 5, the spinous process; 6, transverse process; 7, 7′, superior and inferior articulating processes; *e*, the mammillary tubercle, apparently on the superior articulating process; *f*, the accessory tubercle, between the articulating and transverse processes.

The *articulating processes* are thick and strong. Their articular surfaces are placed vertically and curved so as to lie in the arc of a circle. Those of the superior pair, concave, look backwards and inwards; those of the inferior, convex, look forwards and outwards. The superior pair are further apart than the inferior, and embrace the inferior pair of the vertebra above them. From each superior articular process a tubercle projects backwards, which corresponds with the internal tubercles of the dorsal transverse processes, and is also called the *mammillary* process.

The *ring* is large and triangular, or widely lozenge-shaped.

Fig. 4.

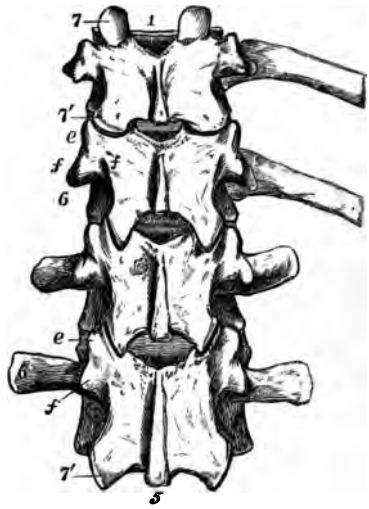


Fig. 4.—Two Lower Dorsal and two Upper Lumbar Vertebræ. ½

with portions of the eleventh and twelfth ribs of the right side: viewed from behind, chiefly to show the relations of the transverse processes and adjacent tubercles. 1, body of the eleventh dorsal vertebra; 5, spinous process of the second lumbar; 6, the transverse process; 7, 7′, superior and inferior articulating processes; *e*, mammillary, and *f*, accessory tubercle. These indications are placed only on the alternate vertebræ to avoid crowding the figure.

CERVICAL VERTEBRÆ.

The cervical vertebræ are seven in number. The first and second are so peculiar in form that they require a separate description. The following characters belong to the five lower vertebræ:—

The *body* is small, and broader from side to side than from before back-

wards. Its superior surface is rendered transversely concave by the upward projection of its lateral margins, and is sloped down anteriorly. The under surface, on the contrary, is rounded off at the sides, while its anterior margin forms a marked projection downwards.

The *laminæ* are remarkable for their length and flatness. The superior *notches* are deeper than the inferior.

The *spinous process* is short, projects horizontally backwards, or is only slightly depressed, and is bifid at its extremity. That of the seventh, however, terminates in a tubercle, and is so long as to be readily felt below the skin, while the others lie more deeply, and are covered with muscles: hence the name *vertebra prominens*, applied to the seventh.

The *transverse processes* are short, and bifid at the extremity. They present a deep groove superiorly, in which the spinal nerves lie; and at the base are perforated vertically by a round foramen of considerable size. They have two roots or points of connection with the vertebra, one in front and one behind the foramen. The posterior root springs from the place of junction of the pedicle and lamina, and in so far corresponds with the dorsal transverse processes; the anterior root is attached to the body of the vertebra and ranges in the same line with the ribs. The foramen corresponds with the space left between the root of a dorsal transverse process and the neck of the attached rib: it gives passage usually in the upper six vertebræ to the vertebral artery and vein, but in the seventh, though the foramen likewise exists, those vessels rarely pass through it. The transverse process of the seventh cervical vertebra presents only a slight appearance of a groove on its upper surface, and is widened rather than bifid at its extremity.

Fig. 5.

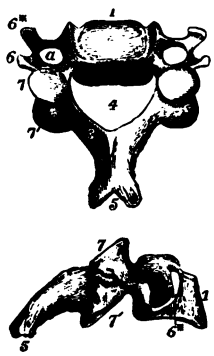


Fig. 5.—Third Cervical Vertebra. $\frac{1}{2}$

A, from above and slightly from behind; B, from the side. 1, the body; 2 (omitted), the pedicle and inter-vertebral notch; 3, lamina; 4, vertebral ring, of a triangular form; 5, bifid spinous process; 6, 6*, transverse process—6, posterior, 6*, anterior tubercle; *a*, foramen in the root of the transverse process transmitting the vertebral artery; 7, 7', articulating processes—7, the superior, 7', the inferior.

The *articulating processes* are large and flat. Their articular surfaces are situated obliquely, the superior pair looking backwards, upwards, and in most of them slightly inwards; the inferior pair forwards, downwards, and in most of them slightly outwards. The portion of bone between the superior and inferior articular surface on each side forms a short vertical pillar.

The *ring* is of a triangular form, and larger than in either the dorsal or lumbar vertebræ.

THE FIRST AND SECOND CERVICAL VERTEBRÆ.

The First Vertebra, or *Atlas*, so called from supporting the head, is remarkable for the smallness of the parts occupying the position of the body and spinous process.

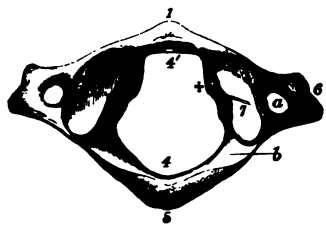
The *ring*, which is large from before backwards, is wider in the posterior than the anterior part of its extent. The wide posterior part corresponds to

the rings of the succeeding vertebræ; the narrower anterior part is occupied by the odontoid process of the axis, and in the recent state is separated

Fig. 6.—The Atlas Vertebra, from above. ½

1, the anterior arch, with a tubercle in front; 4, the posterior part of the ring, with 5, an indication of a spinous tubercle; 4′, the anterior part of the ring, containing the odontoid process, and indicating in front of 4′ the smooth surface on which the process moves in rotation; 6, the transverse process with a slight indication of division into two tubercles; 7, the condyloid articulating process; + inside it indicates the rounded tubercle to which the transverse ligament is attached; *a*, the foramen in the transverse process; *b*, the groove on the posterior arch for the vertebral artery.

Fig. 6.



from the posterior by the transverse ligament of the atlas. In front of the ring is the *anterior arch*, sometimes called the body, from which projects forwards the *anterior tubercle*, while its posterior aspect presents an articular surface which glides in rotation of the head upon the odontoid process of the axis. At the sides of the ring are the *lateral masses*—two stout portions of bone which receive the weight of the head, and present large articular surfaces on their superior and inferior aspects. They are situated in front of the places of exit of the nerves, and in this and other respects differ from the articular processes of the five lower cervical vertebræ. The superior articular surfaces, which receive the condyles of the occipital bone, are of oval form, converging in front, concave from before backwards, and looking inwards as well as upwards. At the internal margin of each is a rounded smooth tubercle with a rough depression, which gives attachment to the transverse ligament. The inferior articular surfaces are smaller than the superior pair, flat, nearly circular, looking downwards and inclined a little inwards.

The *laminæ* unite behind to form a *posterior tubercle*, the rudiment of a spinous process. They are thick and round in the greater part of their extent, but at their junction with the lateral masses they are flattened by a smooth transverse groove on the upper border of each, marking the course of the vertebral artery as it passes inwards from the foramen of the transverse process before entering the cranium. This groove is sometimes converted into a foramen by a small arch of bone. It transmits the sub-occipital nerve as well as the vertebral artery, and corresponds with the notches of the other vertebræ.

The *transverse processes* project considerably further outwards on each side than those of the vertebræ immediately following; they are flattened from above downwards and somewhat rough, they are rounded at the extremity, and at the root of each is the foramen which transmits the vertebral artery.

The Second Vertebra, *Vertebra dentata*, or *Axis*, forms a pivot on which the head with the first vertebra rotates.

The *body* is surmounted superiorly by the odontoid process, and is somewhat narrowed and prolonged below to fit into the depression of the body of the third vertebra. In front it presents a low vertical ridge, with a depression on each side, to which the upper part of the longus colli muscle is attached. The *odontoid process* (p. dentatus) consists of an enlarged

extremity termed the *head*, and a narrower lower part or *neck*. It presents in front a smooth surface for articulation with the atlas, and behind, a smooth groove to receive the transverse ligament of the atlas. The study

Fig. 7.

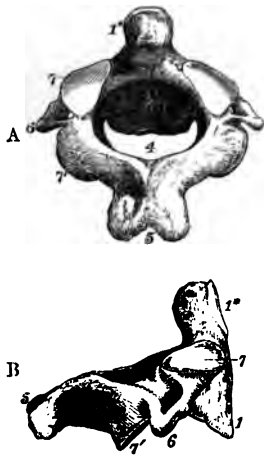


Fig. 7.—The Axis Vertebra. ½

A, seen from above and behind; B, seen from the right side. 1, the body; 4, the vertebral ring or foramen; 5, the spinous process, bifid and very large; 6, the transverse process; 7, the superior articulating process; 7′, the inferior oblique articulating process; 1* in A, is placed at the side of the odontoid process; in B, in front of it, marking the smooth surface of articulation with the anterior arch of the atlas.

of development appears to show that the odontoid process is in reality the body of the atlas anomalously connected with the vertebra dentata. The superior articular surfaces, placed, like those of the atlas, in front of the intervertebral groove, lie on the sides of the base of the odontoid process, partly on the body and partly on the arch of the vertebra. These surfaces look upwards and slightly outwards, and are of considerable size; they receive the weight of the head transmitted through the lateral masses of the atlas. The inferior articulating processes, separated by a notch from the body, are similar in form and position to those of the succeeding vertebræ.

The *spinous* process is very large, rough, and deeply bifid, affording attachment to several muscles, and is grooved on its inferior surface. The plates which support it are of proportionate size and strength.

The *transverse* processes are short, and are scarcely grooved or bifurcated. The foramen at the root of each is inclined obliquely downwards and inwards.

THE FIXED OR UNITED VERTEBRÆ.

THE SACRUM.

The sacrum (os sacrum) is placed below the last lumbar vertebra, above the coccyx, and between the ossa innominata, and forms the upper and back part of the pelvis. It consists in early life of five vertebræ, which in the adult are united into one bone. The first of the five is the largest vertebra in the column; those which follow become rapidly smaller, and the fifth is rudimentary. Hence the sacrum is massive above and slender below, and is triangular in general form, with its base directed upwards. It is concave and smooth in front, convex and uneven behind. The direction of its surfaces is very oblique, its pelvic aspect looking downwards and forwards, and forming at the place where it meets with the last lumbar vertebra the projection termed *promontory*. It presents for consideration a pelvic, a dorsal, and two lateral surfaces, a base and an apex, together with the sacral portion of the spinal canal.

The *pelvic surface* is concave from above downwards, and slightly so from side to side. It is marked across the middle by four transverse lines or

ridges, which indicate the places of union of the bodies of the five vertebræ; and at the extremities of these ridges are situated on each side four *foramina* called *anterior sacral*, which transmit the anterior divisions of the sacral nerves. These foramina are sloped externally into grooves, and diminish gradually in size from above downwards.

Fig. 8.

Fig. 8.—Sacrum of the Male, viewed from before. ½

1, 1, four transverse ridges, indicating the place of original separation of the bodies of the five sacral vertebræ; 2, anterior sacral formina; 3, 4, lateral surface; 5, a notch which, with the coccyx, forms a passage for the fifth sacral nerve; 6, oval surface of the upper part of the sacrum for articulation with the body of the last lumbar vertebra; 7, superior articular processes; 8, inferior oval surface for articulation with the coccyx.

The *dorsal surface* is convex, very uneven, and somewhat narrower than the pelvic surface. It presents along the median line four small eminences, the spinous processes, usually more or less connected, so as to form a ridge. Below the last spinous process is a triangular opening, the termination of the spinal canal, the lateral margins of which are formed by the imperfect laminæ of the fifth sacral vertebra, and present a pair of tubercles, the *sacral cornua*, which project downwards, and articulate with the cornua or horns of the coccyx. On each side of the ridge of spines the surface is smooth and hollowed in the position of the united laminæ, and beyond this surface are two rows of eminences, the inner of which corresponds with the articular and mammillary processes of the lumbar vertebræ, while the outer ranges with the transverse processes. In the groove between the two rows are placed the four *posterior sacral foramina*, which are smaller than the anterior, and transmit the posterior divisions of the sacral nerves.

The lateral aspect or border presents anteriorly a large uneven surface, covered in the recent state with cartilage, which articulates with the ilium, and is called from its shape the *auricular surface:* behind this it is rough and very uneven for the attachment of the posterior sacro-iliac ligaments. Lower down, the margin of the sacrum is thin and sinuous, giving attachment to the sacro-sciatic ligaments, and terminates in the *inferior lateral angle;* below which the breadth of the bone is suddenly contracted, so that with the adjacent part of the coccyx a notch is formed for the transmission of the fifth sacral nerve.

Fig. 9.

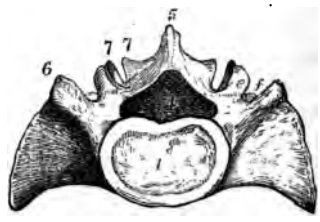


Fig. 9.—Upper Surface or Base of the Sacrum of a Male, to compare with Fig. 3, A, of the Lumbar Vertebra. ½

1, the body; 4, the foramen, ring, or sacral canal; 5, the spinous process of the first sacral vertebra; 6, the part corresponding to a transverse process, in front of which is the large lateral mass; 7, the superior articulating process; 7′, the inferior articulating process; *e*, the mammillary tubercle; *f*, the accessory tubercle, slightly seen.

The *base*, looking upwards and forwards, presents in the middle an oval

surface which articulates with the body of the last lumbar vertebra, and behind this, a triangular aperture, which leads into the sacral canal, and is bounded behind by the sharp depressed border of the laminæ of the first sacral vertebra. On each side of the aperture is an articulating process with a vertical articular surface looking backwards and inwards like the superior articulating processes of the lumbar vertebræ. In front of this is a groove which forms part of the last lumbar intervertebral foramen. The external portion of the base presents posteriorly an eminence corresponding to the lumbar transverse process, and in front of that a large smooth convex surface, inclined forwards and continuous with the iliac fossa of the pelvis.

The *apex*, formed by the small inferior surface of the body of the fifth sacral vertebra, is transversely oval, and articulates with the coccyx.

The *sacral canal* is three-sided, curved with the bone, and gradually narrowed as it descends. It opens below on the posterior surface of the bone, between the sacral cornua, where the laminæ of the last sacral vertebra do not unite. From this canal there pass outwards in the substance of the bone four pairs of intervertebral foramina, or short canals, each of which divides externally into an anterior and posterior sacral foramen.

Curvature.—The curve of the sacrum varies greatly in different skeletons: in some it is slight and confined to the lower end, while in others it is observable in the whole length, but especially about the middle.

Differences in the sexes.—The sacrum of the female body is broader in proportion to its length than that of the male, so as to approach the form of an equilateral triangle, and is seldom curved greatly, or in its whole extent. The sacrum of the female also usually inclines backwards from the direction of the lumbar vertebræ to a greater extent than that of the male.

Varieties.—The sacrum is subject to numerous and considerable variations. It not unfrequently consists of six pieces, and it has been found, but much more rarely, reduced to four. (Sœmmerring, "Lehre von den Knochen und Bändern, &c., herausgegeben von Rudolph Wagner," 1839, p. 128.) It is not fully determined whether these differences depend on increased development of the first coccygeal vertebra and on diminished development of the fifth sacral, or whether there may not be an interposition of a new vertebra in one instance, and the loss of one of the ordinary series in the other. Occasionally the bodies of the first and second sacral vertebræ are not joined, although complete union has taken place in every other part; and in like manner sometimes a space is left between their arches. The lower end of the sacral canal may be open to a greater extent than usual, in consequence of some of the vertebral laminæ not having reached the middle line posteriorly: it has even been found open in its whole extent. (Thomson.) Instances occur in which the first sacral vertebra has on one side the usual sacral form, while on the other it has the appearance of a lumbar vertebra, and occasionally it presents characters on both sides, intermediate between those of the sacrum and lumbar vertebræ.

THE COCCYX.

The coccyx consists most commonly of four rudimentary vertebræ; sometimes of five, seldom of only three. The coccygeal vertebræ diminish gradually in size from above downwards, and are placed in a continuous line with the lower part of the sacrum.

The *first* of the series is considerably broader than the others. It presents superiorly a small oval concave surface which articulates with the apex of the sacrum, two lateral projections corresponding with those of the last sacral vertebra, and two small processes, termed *cornua*, corresponding to a certain extent with articulating processes, which project upwards from its posterior aspect and rest upon the sacral cornua. The lateral parts project

outwards, usually forming with the sacrum the notch for the fifth sacral nerve, and in some instances uniting with the sacrum so as to form a fifth sacral foramen.

Fig. 10.

Fig. 10.—Four Coccygeal Vertebræ, seen from before.—From a Male Subject of Middle Age. ½

The upper piece is separate from the second; the three lower are united together in one piece, and separated only by grooves. 1 is placed above the middle or body of the first coccygeal vertebra; 1′ is below the fourth piece; 6 indicates the transverse portion; 7, the superior articulating tubercle.

The remaining three coccygeal vertebræ are much smaller than the first, and correspond solely to vertebral bodies. When separate, the second piece presents an upper and lower flattened surface. The third and fourth pieces are mere rounded nodules. In middle life, the first piece is usually separate, while the three lower pieces are most frequently united into one, the original separation being indicated only by transverse grooves.

In advanced life, the coccygeal vertebræ, having been previously joined into one bone, become also united to the sacrum. This union occurs at an earlier age and more frequently in the male than in the female, but it is subject to much variation.

THE VERTEBRAL COLUMN AS A WHOLE.

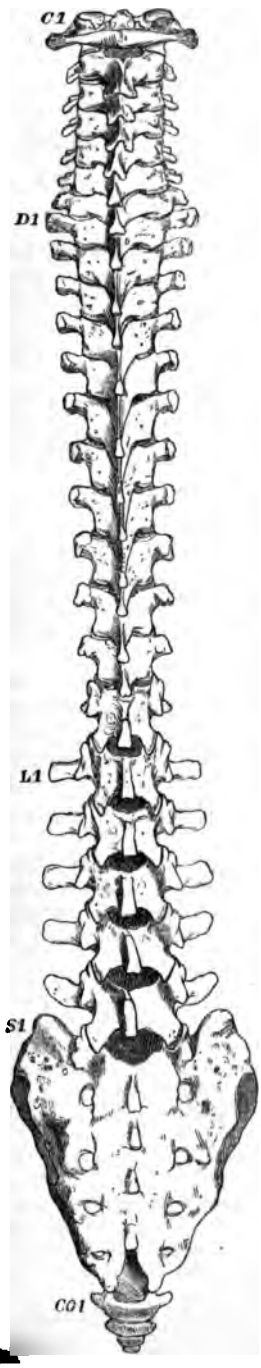
The *average length* of the vertebral column is about twenty-eight inches. Its length varies to a considerable extent in different persons, but not so much as might be anticipated from a comparison of their stature; the relative height of individuals depending more frequently on a difference in the length of their lower limbs than of the vertebral column.

Curves.—The vertebral column presents four curves, directed backwards and forwards. In the neck and loins the convexity is forwards; in the back and pelvis it is in the opposite direction. The lumbar convexity is much greater than the cervical; and the sacral concavity is greater than the thoracic. In the dorsal region, there is also very frequently a slight degree of lateral curvature, the convexity of which in the great majority of cases is directed towards the right side.

In connection with the thoracic concavity of the column, the bodies of the dorsal vertebræ are somewhat thinner in front than behind. The pelvic concavity is chiefly dependent on the diminished vertical diameter of the bodies of the sacrum in front, and the bending forward of the coccyx. The cervical and lumbar convexities are attended with a slightly greater thickness of the posterior than of the anterior parts of the intervertebral discs, and they are in part maintained by the elastic tension of the ligamenta subflava acting upon the most flexible portions of the column. (W. & E. Weber, "Mechanik der Mensch. Gewerkzeuge," p. 91; and Henle, "Handbuch der Syst. Anat. des Menschen," vol. i., p. 32.) These curves are connected with the maintenance of the erect posture. They are absent in infants and increase towards adult age. They confer upon the column the advantages of a spring, giving it greater strength and elasticity, and at the same time assist in preserving the equilibrium of the body.

The lateral curvature in the dorsal region has been supposed by some anatomists to be connected with the position of the aorta on the left side of the column. Cruveilhier mentions, in support of this opinion, three cases of transposition of the aorta, in which the convexity of the lateral curve was directed to the left side. (Cruveilhier, "Traité d'Anatomie," 4th edit., p. 65.) By a majority of writers this curve is imputed to the greater muscular action on the right side than the left, occasioned by the preference usually given to the right arm. This explanation originated with Bichat. Otto describes a case of right aorta, in which the curve of

Fig. 11.



the column had the usual direction, and in which the right arm was more muscular than the left. ("Seltene Beobachtungen," part 2, p. 61; see also R. Quain, "Anatomy of the Arteries," p. 19.)

Fig. 11.—Vertebral Column of an Adult Male, seen from behind. ¼

C 1 to above D 1, the seven cervical vertebræ; D 1 to above L 1, the twelve dorsal vertebræ; L 1 to above S 1, the five lumbar vertebræ; S 1 to above CO 1, the sacrum; CO 1, and below, the four coccygeal vertebræ. The attention of the reader is called to the transition in the form of the transverse processes and tubercles indicated in this specimen, which is well marked.

Form.—On the *anterior* aspect of the column, the pillar formed by the bodies of the vertebræ is seen to become broader from the axis to the first dorsal vertebra. At this place it ceases to widen, and even becomes slightly narrower from the first to about the fourth dorsal vertebra; from that level it then becomes gradually wider down to the base of the sacrum. The width between the extremities of the transverse processes is considerable in the atlas; it is small in the axis, becomes greater as far as the first dorsal vertebra, thence it is again gradually contracted as far as the last dorsal, and becomes suddenly much greater in the lumbar region.

On the *lateral* aspect, the diameter of the bodies from before backwards is seen to increase most rapidly in the dorsal region. The tips of the transverse processes of the dorsal vertebræ, being directed backwards, describe a greater curvature than the bodies; while the spinous processes exhibit a smaller curvature, on account of the middle dorsal set being most sloped downwards, while those above and below project backwards.

On the *posterior* aspect, the spines occupy the middle line. Those of the dorsal region are in many instances inclined a little, some to one side and some to the other. At the sides of the row of spines are the vertebral grooves, corresponding to the laminæ, and bounded externally in the cervical and dorsal regions by the transverse processes, and in the lumbar by the mammillary processes. They are broad but shallow in the neck, and become deep and narrow lower down; the narrowest part being at the last dorsal vertebra. Along the grooves is a series of spaces between the laminæ, which, in the natural condition, are filled up by the yellow ligaments. The extent

of these intervals is very trifling in the neck and in the greater part of the back, it increases in the lower third of the dorsal, and still more in the lumbar region. The interval between the occipital bone and the arch of the atlas is considerable, and so is that between the last lumbar vertebra and the sacrum.

Fig. 12.

Fig. 12.—The same Vertebral Column as in Fig. 11, viewed from the Left Side. ¼

The letters and figures indicate the several vertebræ. The attention of the reader is called to the different curvatures of the column here shown, the shape and size of the bodies and intervertebral spaces, the form and transitions of the transverse and spinous processes, and the differences in the costal articulating surfaces.

DEVELOPMENT OF THE VERTEBRÆ.

Earliest steps of fœtal development as related to the first formation of the Vertebral Column and Skeleton.—The first step in the formative process within the ova of vertebrate animals is the production on the surface of the yolk of a superficial layer of organised cells, termed *blastoderm*, or *germinal membrane*. In the progress of development, this substance very soon comes to be divided into three strata or layers, which may be distinguished from each other by their structural differences, and have been named from their position the upper, middle, and lower layers of the germinal membrane. The upper and lower layers retain throughout their simple cellular structure, and take no share in the formation of the skeleton. From a part of the upper layer the medullary rudiments of the brain and spinal marrow are derived; while the rest of its extent is the source of the cuticular covering of the body. The whole of the deeper layer is taken up in the formation of the epithelium of the mucous membranes of the alimentary canal and its dependencies. But the middle layer has a far more complex and important destination, as it furnishes the formative material from which are developed the rudiments of the osseous, muscular and vascular systems, together with the peripheral nerves, the fibrous coats of the alimentary canal, and many other parts of the body.

The earliest indication of embryo-form consists in the production of the *primitive trace* and groove, which takes place in the part of the upper and middle layers to be occupied by the embryo. The deepening of this groove by the elevation of its sides lays the foundation of the cerebro-spinal canal or cavity, and this is finally closed in superiorly by the meeting and union of the elevated and approximated

margins of the groove. At the same time there is enclosed within the cavity the medullary substance derived from the upper layer, which constitutes the rudiment of the brain and spinal marrow.

It is below and around this tubular cerebro-spinal cavity, and in the substance of the portion of the middle germinal layer immediately adjacent to it, that the cranio-vertebral part of the skeleton takes its origin by steps of which the following is the briefest possible outline.

Immediately below the cerebro-spinal groove, previous to its closure, there appears in the substance of the middle layer a linear condensed structure, termed *chorda dorsalis* or *notochord;* round this at a later period the base of the skull and bodies of the vertebræ are developed. The chorda dorsalis may be seen in the embryo-chick after eighteen hours of incubation, and at corresponding periods of advancement in the embryoes of mammalia. In the human embryo, although the first origin of this chord has not yet been observed, there is no reason to doubt its existence; and from observations at a later period of development it is certain that the foundation of the human skeleton is laid in a manner essentially the same as in animals.

Soon after the extension of the two upper germinal layers in the dorsal direction has given rise, in the manner mentioned, to the neural cavity and its contained cerebro-spinal axis, the incurvation of all the three germinal layers in a downward or ventral direction results in the formation of the walls of the visceral cavities of the body; and thus from the chorda dorsalis as a centre there proceeds upwards a neural and downwards a visceral arch.

In the middle layer itself, which is destined for the production of the most complicated parts, the thickened portion which is next to the chorda dorsalis on either side is separated from the part which is more remote, and it is in the inner portion now mentioned that there are produced at a very early period those structures which have been called *primitive* or *primordial vertebræ* by embryologists, the formation of which constitutes the next stage in the progress of the earliest development of the skeleton. These rudimental structures consist of small dark quadrilateral patches of condensed germinal substance, to the number of three or four, situated on each side of the chorda dorsalis. The anterior of them corresponds to the atlas vertebra, and in the subsequent increase of their number, the new ones make their appearance farther and farther backwards, or towards the caudal extremity.

Fig. 13.

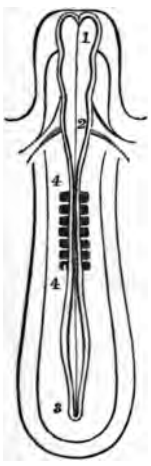


Fig. 13.—This and the three following figures are intended to illustrate the first formation of the vertebral segments, or "primitive vertebræ," and some of the changes by which the permanent vertebral and costal arches are produced. Fig. 13 gives in outline a magnified view of the embryo of the chick about twenty-six hours after the commencement of incubation, as it lies prone in the centre of the germinal membrane. 1, 2, 3, cerebro-spinal canal; 1—2, the cerebral part; 2—3, the spinal part, not yet closed in the caudal region; 4—4, seven primitive vertebræ, proto-vertebræ, or vertebral segments; near 2, the rudiments of the heart.

The so-called primordial vertebræ have, however, a more extended destination than to serve as the basis of formation of the elements of the vertebral column; for each pair of them contains the rudiments, not only of the osseous and cartilaginous parts of a vertebra which cross the middle plane, but also in the thoracic region a portion of a rib, and throughout the whole extent the central parts of a spinal pair of nerves and the cutaneous and muscular parts which cover the whole vertebral region. The process by which these several parts come to be distinct in the progress of development is somewhat intricate. It will be sufficient to mention here that, after a considerable change has occurred in each of the primordial vertebral masses by the rapid formation of cells within them, each becomes cleft into an upper and lower (dorsal and ventral) division or plate. The upper constitutes the basis of the skin and muscles of the vertebral part of the trunk, while the lower or deeper portion undergoes further division in connection with the development of very

dissimilar elements from its substance. In the first place, the outer half of each is divided by a transverse fissure into two parts, of which the anterior, or that towards the head, is afterwards converted into the root and ganglion of a spinal nerve;

Fig. 14.

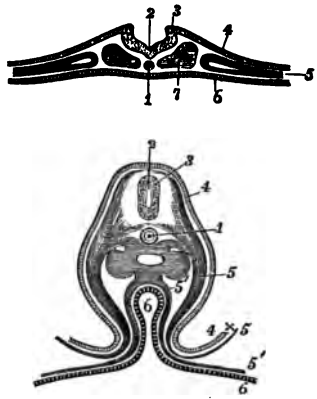


Fig. 14, A. — Transverse section through the spinal part of the embryo represented in fig. 13, at the place where the spinal canal is still open, or is only a groove. 1, chorda dorsalis; 2, spinal canal or primitive groove; 2 to 3, medullary plates, continuous with 4, the corneous layer of the blastoderm; 5, the middle layer; its outer part divided into two laminæ, the upper being the volunto-motory, in which osseous and muscular plates afterwards make their appearance, and the lower being the involunto-motory or intestino-fibrous lamina; 6, the epithelial, or lowest layer of the blastoderm; 7, the inner part of the middle layer, in which the primitive vertebral segments are developed.

Fig. 14, B (adapted from Remak and Kölliker).—Transverse section of the lumbar part of an embryo more advanced, or towards the fifth day, showing the spinal canal and spinal marrow closed, the visceral plates and intestine formed, &c. 1, chorda dorsalis in its sheath; 2, canal of the spinal marrow; 3, medullary substance of the spinal marrow; 4, corneous layer; 5, outer lamina of the middle layer forming the visceral plates, and along with the corneous layer the amnion 4 × 5; 5′, inner lamina of the middle layer or intestino-fibrous; the figure 5′ is placed in the peritoneal cavity; immediately above it are seen the rudiments of the Wolffian bodies, the aorta in the middle between them, and on each side the Wolffian duct; 6, the intestinal cavity and epithelial layer, extending at 5′, 6, into the blastoderm of the yolk sac.

and the posterior is the source of the transverse process of a vertebra and adjacent portion of a rib. The inner part of the primordial vertebral mass passes inwards in two modes: 1st, by its deepest part it passes above and below the chorda dorsalis, and joining with the corresponding structures from the opposite side, surrounds

Fig. 15.

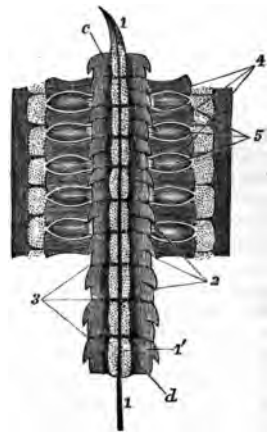


Fig. 15 (from Remak and Kölliker).—The cervical part of the primitive vertebral column and adjacent parts of an embryo of the sixth day, showing the division of the primitive vertebral segments into permanent vertebral arches, rudiments of the spinal nerves, &c. 1, 1, chorda dorsalis in its sheath, pointed at its upper end; 2, points by three lines to the original intervals of the primitive vertebræ; 3, in a similar manner indicates the places of new division into permanent bodies of vertebræ; *c* indicates the body of the first cervical vertebra; in this and the next the primitive division has disappeared, as also in the two lowest represented, viz., *d* and the one above; in those intermediate the line of division is shown: 4, points in three places the vertebral arches; and 5, similarly three commencing ganglia of the spinal nerves: the dotted segments outside these parts are the muscular plates.

the chorda; 2nd, its more superficial part completes the formation of a ring, or a part of a cylinder, round the spinal cord. This may be considered as the

membranous stage in the development of the vertebral column. It may be proper to remark that there is no similar original division in the cephalic portion of the primordial skeleton, but the chorda dorsalis is prolonged for a short distance into the middle of the basilar part.

The process of breaking up of the primordial vertebral masses above referred to is followed by a reconstruction, as it were, of the vertebræ, which consists in this—that in the cylinder investing the chorda dorsalis the lines of separation of the primordial vertebral masses fade away, while midway between them new lines appear, marking the limits of the permanent vertebræ; and thus each permanent vertebra is formed from parts of two of the primordial masses; the arch, the transverse processes and part of the ribs, together with half the body, being derived from one primitive vertebra, and the remaining half of the body together with the corresponding pair of nerves proceeding from a part of the next primordial mass in succession.

In the human embryo, the vertebral column begins to become cartilaginous in the sixth or seventh week. The cartilage spreads rapidly over the bodies, but much more slowly into the arches, in which the union of the cartilages of opposite sides is not completed till during the fourth month (Kölliker). At the period of the first appearance of the cartilaginous bodies, the chorda dorsalis consists of a solid column of large thin-walled cells, surrounded by a transparent sheath; but it becomes constricted, and gradually dwindles within each vertebral body, while it remains more fully developed in the intervertebral spaces, and enters into the formation of the intervertebral discs.

Fig. 16.

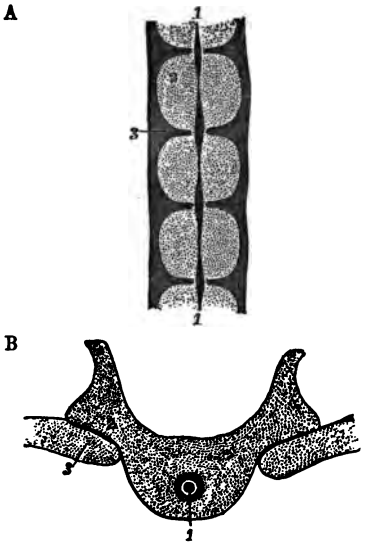


Fig. 16, A & B (from Kölliker, figs. 80 & 81). —Sections of the Vertebral Column of a Human Fœtus of eight weeks.

A, transverse longitudinal section of several vertebræ. 1, 1, chorda dorsalis, its remains thicker opposite the intervertebral discs; 2 is placed on one of the bodies of the permanent vertebræ; 3, on one of the intervertebral discs.

B, transverse horizontal section through a part of one dorsal vertebra. 1, remains of the chorda dorsalis in the middle of the body; 2, arch of the vertebra; 3, head of a rib.

Ossification.—The ossification of each typical vertebra proceeds from three principal nuclei. One of these, which is occasionally double at first, appears in the middle of the cartilage, and is afterwards converted into the main part of the body; the other two, placed one on each side, appear opposite the roots of the transverse processes, usually a little earlier than the nucleus of the body; and form the arch and processes, together with an angular part on each side of the body, namely, that part which in the dorsal region supports the heads of the ribs. At different periods subsequent to the age of puberty, five epiphyses, or supplementary centres of ossification, are added. Three of these are small portions of bone, placed on the tips of the spinous and transverse processes: the other two are thin circular plates, one on the upper, the other on the lower surface of the body, chiefly at its circumference. In the lumbar vertebræ two other epiphyses surmount the mammillary processes. The transverse process of the first lumbar vertebra is sometimes observed to be developed altogether from a separate centre. Most of the anterior divisions of the cervical transverse processes are ossified by the extension into them of osseous substance from the neighbouring posterior part of the process and from the arch; but that of the seventh usually presents a separate osseous nucleus, and small nuclei have also been observed by Meckel in those of the second, fifth, and sixth vertebræ.

In the atlas, the lateral masses and posterior arches are ossified from a pair of centres corresponding to those in the arches of the succeeding vertebræ. In the anterior arch one or two separate nuclei appear soon after birth; and even three have been observed. There is frequently a small epiphysis on the posterior tubercle.

Fig. 17. — ILLUSTRATES THE OSSIFICATION OF THE VERTEBRÆ.

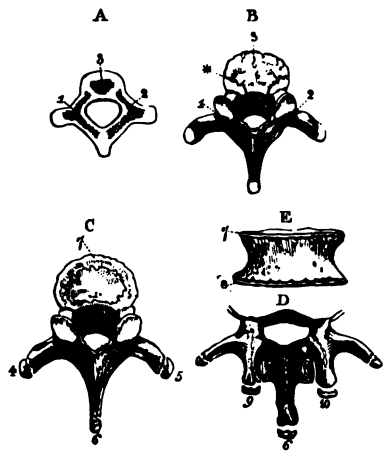
A, fœtal vertebra, showing the three primary centres of ossification; 1, 2, for the pedicles, laminæ, and processes; 3, for the body.

B, dorsal vertebra from a child of two years, as seen from above; 1 & 2 are seen to have encroached upon the body at *, and into the articular and transverse processes, and to have united behind in the spinous process, leaving cartilaginous ends.

C, dorsal vertebra at about sixteen or seventeen years, showing the epiphyses on the transverse processes, 4 & 5, and spinous process, 6, and the upper epiphysial plate of the body, 7.

D & E, parts of a lumbar vertebra of about the same age, showing, in addition to the foregoing, 8, the lower epiphysial plate of the body; 9 & 10, the epiphyses of the superior articular processes (mammillary tubercles).

Fig. 17.



In the axis there appear, about the same time as in the other vertebræ, a pair of osseous centres in the arch, one or two in the body (Cruveilhier), and shortly afterwards a pair in the odontoid process which very soon unite together. At birth, the odontoid process is of larger size than the body, from which it is still distinct; and its general appearance confirms the evidence of comparative anatomy, that it is to be regarded as the displaced body of the atlas.

Fig. 18.—OSSIFICATION OF THE ATLAS AS SEEN FROM ABOVE.

A, the atlas before birth; 1 & 2 ossified deposits in the posterior parts of the arch; the anterior part is cartilaginous.

B, the atlas of a child in the first year; 1 & 2, as before; 3, the point of ossification in the anterior arch.

Fig. 18.

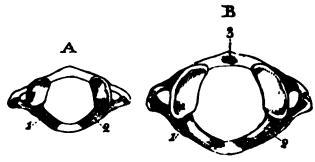


Fig. 18.*—OSSIFICATION OF THE AXIS AS SEEN FROM THE FRONT.

A, the axis of the fœtus of seven months, showing at 3 the centre for the body, and at 4 & 5 two centres for the base of the odontoid process.

B, the axis shortly after birth, showing at 1 & 2 the centres for the arch; 3, the centre for the body; 6, the two centres of the odontoid process united into one.

Fig. 18.*

The sacral vertebræ present the three ordinary great centres of ossification, viz., one in the body, and a pair in the arch; but in each of the first three or sometimes four sacral vertebræ the anterior part of the lateral masses on each side is formed

from an additional centre. On the body of each sacral vertebra, epiphysial plates are formed at a later period, as in other vertebræ. To complete the ossification of the sacrum, there are also formed on each side of it two flat and irregular plates, of which one extends over the first three vertebræ, while the other connects the last two.

Fig. 19.

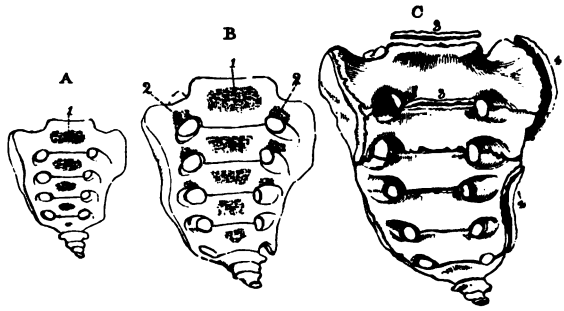


Fig. 19.—Ossification of the Sacrum.

A, sacrum of a fœtus before six months, seen from the front, showing the ossific nucleus n the body of each vertebra, from 1 downwards.

B, sacrum of a child at birth, showing three pairs of additional nuclei for the lateral masses, 2, 2, close above the sacral foramina.

C, sacrum of a person of about twenty-five years of age. At 3 & 3, epiphysial plates are still visible above and below the first vertebral piece, and the fissures still remain between the first and second and the second and third lateral pieces; at 4 & 4' are shown the lateral epiphysial plates.

Each of the coccygeal vertebræ is usually ossified from a single centre; but occasionally one of the first three contains two granules placed side by side.

Progress of Ossification in the Vertebral Column.—The deposit of bone in the arches of the vertebræ takes place first in those belonging to the upper end of the column, and gradually proceeds downwards. In the bodies, it first occurs in the lower part of the dorsal region (about the ninth dorsal vertebra); and from that the process is extended upwards and downwards, reaching last of all the atlas and the coccyx, neither of which ossify till after birth. But though the nuclei of the lower dorsal vertebræ are the first to appear, they are soon surpassed in size by those below them; and in the fœtus at birth the relative size of the nuclei corresponds with that of the fully-grown vertebræ.

In the subjoined table are stated the ages at which the osseous centres of the vertebral column appear and the steps of union take place. But it is to be observed that it is only attempted to state these ages approximately, both because of the great difficulty, in most instances, of determining the age of the human fœtus with accuracy, and because of a certain amount of variety which probably exists in the rapidity of the growth of bone in different cases. (See Albinus, "Icones Ossium fœtus," p. 68; Meckel, in his "Archiv" vol. i. 1815, p. 648, tab. vi.; Humphry, "On the Skeleton," p. 132; Aitken, "Growth of the Recruit," 1862.)

PERIODS OF OSSIFICATION OF THE VERTEBRÆ.

In the vertebræ generally—

The three primary centres appear in the 7th or 8th week (fœtal life).
The epiphyses of the processes appear in the 18th year or later.
The epiphysial plates of the body appear in the 18th or 20th year.
The two centres of the arch unite in the first year.

In the vertebræ generally—
The arch and the body unite in the 3rd year.
The vertebra and its epiphyses unite in the 25th year or later.
In the atlas—
Ossification of the anterior arch appears in the 1st year.
The two centres of the posterior arch unite in the 3rd year.
The anterior and posterior arches unite in the 5th or 6th year.
In the axis—
The centre of the body and (a little later) the centres of the odontoid process appear in the 6th month.
The body and odontoid process unite in the 3rd year.
In the sacrum—
The additional lateral centres appear from the 6th to the 8th month.
The lateral epiphysial plates appear from the 18th to the 20th year.
The body and arch unite in the 5th vertebra in the 2nd year.
The body and arch unite in the 1st vertebra in the 5th or 6th year.
The lower vertebræ unite with one another in the 18th year.
The upper vertebræ unite with one another in the 25th year or later.
In the coccyx—
Ossification of the 1st vertebra appears about the time of birth.
Ossification of the 2nd vertebra appears from the 5th to the 10th year.
Ossification of the 3rd vertebra appears from the 10th to the 15th year.
Ossification of the 4th vertebra appears from the 15th to the 20th year.

THEORETICAL COMPARISON OF THE VERTEBRÆ.

The study of the correspondence of parts in different vertebræ, or of their homology, involves complicated questions, which cannot be competently discussed without reference to the various forms found throughout the vertebrate classes of animals. But there are some points connected with this subject to which the attention of the student of human anatomy may here be briefly directed.

In considering the serial relations of the bodies of the vertebræ, it is necessary to distinguish the masses formed round the chorda dorsalis—the *centra*—from the angular portions derived by ossification from the arch. The only peculiarities in the series of centra are to be found at or near the extremities of the column. One of these, of less note, is presented by the first coccygeal vertebra, the cornua and lateral projections of which, although ranged in series with parts which in the preceding vertebræ are derived from the osseous nuclei of the arch, are, nevertheless, ossified from the centrum. The other peculiarity presented by the atlas and axis is of a more remarkable kind. The odontoid process of the axis is the true centrum of the atlas, disguised by remaining distinct from the rest of the vertebra to which it belongs, and becoming adherent to the centrum of the succeeding vertebra. The main proofs that this view is correct are, 1st, that the odontoid process originates in cartilage distinct from the proper centrum of the axis; 2nd, that the remains of the chorda dorsalis have been traced through the odontoid process to the occipital bone; and 3rd, that in early life, and in certain animals (especially turtles), the odontoid process is similar in appearance to the succeeding centra. The anterior nucleus of the atlas must, therefore, be regarded as a pre-central or sub-central structure. (Rathke, "Entwicklungsgeschichte der Natter," p. 120; and "Entwickl. der Schildkröten," p. 77.) It is proper to observe that both sets of the articular surfaces of the atlas and the superior pair belonging to the axis are placed upon those parts which in succeeding vertebræ form the angles of the bodies; these articular surfaces, therefore, correspond in position, not with the smooth facets of the articulating processes, but rather with those for the heads of the ribs in the dorsal vertebræ. This is seen not only from their position in front of the trunks of the spinal nerves, and from the superior articular surfaces of the axis actually abutting on the centrum, but also from the condition of parts in many animals. Thus, in birds and reptiles the lateral masses and anterior nucleus of the atlas unite to form a mesial disc, which articulates with the body of the axis in front of the odontoid process and with a single condyle on the occipital bone, while at the same time the axis and atlas are likewise connected by articulating processes placed behind the nerves and in series with those which follow.

On examination of the series of transverse processes, a certain amount of correspondence cannot fail to be noticed between the anterior divisions of those of the cervical vertebræ and ribs; especially when it is considered that in certain instances those of the seventh cervical vertebra are replaced by ribs which are articulated in two places with the vertebra; and that in the neck of saurian reptiles short ribs are found very similar in appearance to the anterior divisions of the transverse processes in the human subject. On the other hand, these processes differ from ribs in being for the most part ossified in continuity with the arch; and on that account some anatomists prefer to compare them with the costal facets on the dorsal vertebræ, and with processes on which in birds and reptiles those facets are elevated. The transverse, mammillary, and accessory processes of the lumbar vertebræ lie in series, as has been seen, with the three sets of tubercles on the transverse processes of the twelfth and other dorsal vertebræ, whence it may be argued, as has been done by Retzius, that the whole transverse process of a dorsal vertebra corresponds to three processes of a lumbar vertebra. At the same time, the mammillary processes are not mere subsidiary parts developed on the transverse processes, for in some animals, as the hedgehog and the armadillo, they are of much greater size than the transverse processes themselves, continue distinct from them in nearly the whole length of the thoracic region, and may be seen to lie in series with prominences on the articulating processes of the cervical vertebræ. The lumbar transverse processes are not without a certain degree of correspondence with ribs, which is illustrated by the first of the series being sometimes replaced by a short thirteenth rib on one or both sides, and is also indicated by the existence on the upper borders of the lumbar transverse processes of grooves, sometimes pretty distinct, which lie in series with the intervals between

Fig. 20.

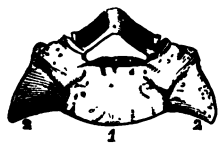


Fig. 20.—Osseous part of the First Vertebra of the Sacrum of a Person of four or five years old. ½

1, the body; 2, 2, the large lateral masses between which and the body and the transverse processes deep fissures are seen running backwards.

the necks of the ribs and the dorsal transverse processes. In the sacrum, the special lateral centres of ossification in the three upper vertebræ may, very probably, be regarded as costal elements. (Retzius, "Müller's Archiv," 1849; J. Müller, "Vergl. Anat. der Myxinoiden;" August Müller, "Müller's Archiv," 1853; Humphry, "Treatise on the Human Skeleton;" Cleland, in "Nat. Hist. Review," 1861 and 1863.)

It is not to be wondered at that the vertebral column, from its being the most regularly segmented structure in the body, as well as from its forming the basis of the osseous system, should have held a prominent place in the various schemes, according to which it has been attempted to resolve the skeleton into a certain number of elements, repeated in modified forms in the different segments. Among the various schemes of this description may be mentioned those of Oken, Carus, Geoffroy St. Hilaire, Owen, Maclise, and Goodsir. (Oken, "Physiophilosophie," and in "Isis," 1817, 1819, 1820; C. G. Carus, "Lehrbuch der Zootomie," 2nd edit.; Geoffroy St. Hilaire, "Philosophie Anatomique;" Owen, "On the Archetype and Homologies of the Vertebrate Skeleton;" Maclise, "Comparative Osteology," and the Article "Skeleton" in "Todd's Cyclopæd. of Anat. and Physiol.;" Goodsir, "Edinburgh New Philosophical Journal," 1857, p. 118.)

Based upon morphological views, there has likewise been introduced by Owen a system of nomenclature, which being adhered to in his descriptive writings, and adopted more or less by various English writers, demands attention. In that system the word *vertebra* is employed to signify a segment of the skeleton, the term *centrum* is preserved in its usual signification, the laminæ are called *neurapophyses*, the spine the *neural spine*, the articulating processes *zygapophyses*, the ribs *pleurapophyses*, the mammillary processes *metapophyses*, and the accessory processes *anapophyses*. Two descriptions of transverse processes are distinguished, viz., the *diapophyses* and the *parapophyses;* the dorsal transverse processes and the posterior parts of the cervical transverse processes being examples of the first, while the anterior parts of the cervical transverse processes are referred to the second. The ideal

arrangement named by Owen the "typical vertebra" is completed by the addition to the parts now mentioned of a pair of *hæmapophyses* and a *hæmal spine*, situated in front of the centrum, as the neurapophyses and neural spine are placed behind; but in the thorax, according to his views, the hæmapophyses are supposed to be transplanted to the extremities of the pleurapophyses, and form the costal cartilages, carrying with them the sternum or series of hæmal spines.

However interesting these views may be, and however expedient the adoption in Comparative Anatomy of some such words, expressive of anatomical relations, more especially when it shall appear that the doctrines suggesting the terminology are sufficiently established; yet, as these are still imperfect, and as the names by which most parts of the human body are commonly designated have been long in use, and are very generally understood, it seems premature for the present to attempt a theoretical reformation of the nomenclature of human descriptive anatomy.

THE THORAX.

The parts which enter into the construction of the thoracic part of the skeleton are the dorsal vertebræ already described, the sternum, the ribs, and the costal cartilages.

THE STERNUM OR BREAST-BONE.

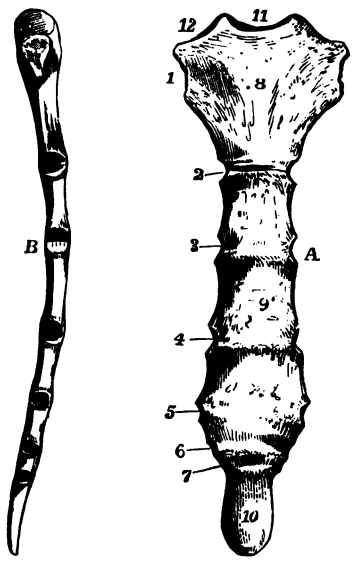
The sternum (*os pectoris, os xiphoides*) is situated at the fore part of the thorax, in a sloping position, inclined downwards and forwards. It is connected with the rest of the trunk by the costal cartilages of the seven highest pairs of ribs, and gives attachment to the clavicles. It consists originally of six segments. The first of these usually remains distinct up to middle life, and is called the *manubrium;* the succeeding four are united into one in the adult, and form the *body;* the sixth generally remains cartilaginous up to the period of puberty, and sometimes partially so even to advanced age, and is called the *xiphoid*, or *ensiform process*, or *cartilage*.

Fig. 21.—The Sternum of a middle-aged Man. ⅓

A, from before, 1, 2, 3, 4, 5, 6, & 7, the articular surfaces for the corresponding costal cartilages; 8, manubrium or upper piece, still slightly separate from the body; 9, middle of the body; 10, ensiform portion, osseous, and united to the body; 11, interclavicular notch; articular notch for the clavicle.

B, the same sternum viewed from the right side, showing the general convexity of the bone forwards. The different facets of articulation of the clavicle and costal cartilages will be distinguished by their position in comparing the figure B with A.

Fig. 21.



The sternum is flattened from before backwards, and presents a slight vertical curve with the convexity in front. It is of unequal width, being

broad at the upper part of the manubrium, considerably narrower at the lower end of that portion and in the following segment, somewhat wider near the lower than at the upper end of the body, and finally compressed and narrowed where the body joins the ensiform cartilage. It consists of light cancellated texture, with a thin covering of compact bone, so as to be liable to crushing from violence.

The *manubrium* is the thickest part of the sternum. Its superior border is divided into three deep notches; the middle one is named the *incisura, furcula,* or *interclavicular notch*; the lateral ones form two depressed articular surfaces directed upwards and outwards, for articulation with the clavicles. Each lateral border presents superiorly a rough depression close to the clavicular surface, but looking directly outwards, which receives the cartilage of the first rib; and, at its inferior angle, a small surface which, with a similar one on the second segment, forms a notch for the cartilage of the second rib. The inferior margin is straight, and united by intervening cartilage to the upper margin of the second segment.

The *body* is marked on its anterior surface by three slight transverse elevations, which mark the lines of junction of its four component parts. Its posterior or thoracic surface, together with that of the manubrium, is of more uniform smoothness. The lateral margins present each five notches for the reception of costal cartilages, and a small surface superiorly, which, with the similar depression on the manubrium, forms the notch for the second costal cartilage.

The notches for the third, fourth, and fifth costal cartilages are opposite the lines of junction of the four segments of the body of the sternum; those of the sixth and seventh are placed close together on the sides of the inferior segment, that for the seventh being frequently completed by the ensiform cartilage.

The lower segment of the bone, often called ensiform cartilage, varies considerably in different individuals. In its simplest form it is a thin spatula-like process projecting downwards between the cartilages of the seventh ribs. It is, however, subject to very frequent varieties of form; being sometimes bent forwards, sometimes backwards, often forked, and sometimes perforated. It projects into the aponeurosis of the abdominal muscles.

The sternum is subject to many varieties. It is sometimes divided vertically in the whole or a part of its length. It is not unfrequently much shorter than usual, and indented at its lower part, as occurs especially from the pressure of the cobbler's last.

Two episternal nodules have been found in some rare cases surmounting the incisura of the manubrium. (Breschet, "Annales des Sciences Naturelles," 2d series, v. 10, Zoologie, p. 191; and Luschka, "Die Halsrippen und die Ossa supra-sternalia," Vienna, 1859.) Their position is indicated by the asterisks (**) in figure 24, E. They derive an additional interest from the occurrence of suprasternal bones in reptiles and monotremata.

THE RIBS.

The ribs (*costæ*) are twelve in number on each side. They form a series of arched and highly elastic bones, which extend outwards and forwards from the vertebral column, and form the lateral walls of the thorax. Their anterior extremities give attachment to cartilaginous prolongations—the costal cartilages, the first seven pairs of which pass forward to the sternum. On this account the first seven pairs of ribs are called *sternal,* or *true* ribs, while the remaining five pairs are called *asternal,* or *false* ribs.

CHARACTERS COMMON TO MOST OF THE RIBS.—These are best marked in the ribs near the middle of the series. The posterior extremity is thickened, and is termed the *head* or *capitulum*; it presents a superior and an inferior oblique articular surface for articulation with the bodies of two vertebræ, and, between them, a slight ridge, to which the interarticular ligament is attached. At a little distance from the head, and separated from it by the neck, is the *tubercle*, which is directed backwards, and presents a smooth surface for articulation with the transverse process of the inferior of the two vertebræ with which the head is connected, and, outside that, a roughness marking the insertion of the posterior costo-transverse ligament. The part termed the *neck*, between the head and the tubercle, is slenderer than the rest of the rib. The whole extent beyond the tubercle constitutes the *body*. It becomes laterally compressed, and wider from above downwards, towards the anterior extremity. Outside the tubercle, between it and the most convex part of the body, is a rough line, which corresponds to the outer border of the erector spinæ muscle, and which is termed the *angle*, because at this point the curve of the rib is more sudden, and changes from an outward and backward to a forward direction. The inferior border presents on its inner aspect a *groove*, in which lie the intercostal vessels and nerve, and which is best marked opposite the angle, and disappears in front. The anterior extremity is hollowed at its tip into an oval pit, into which the costal cartilage is implanted.

Fig. 22.

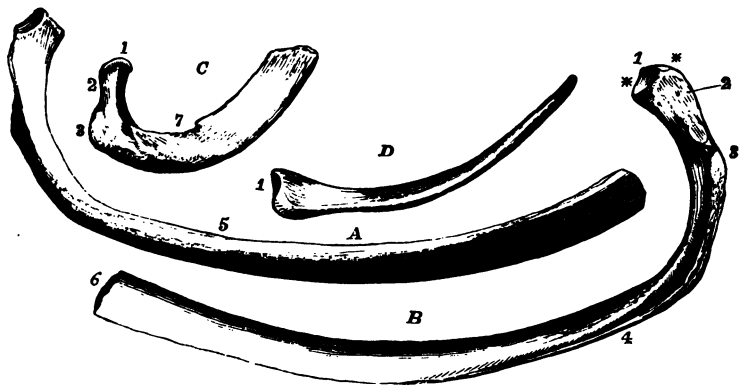


Fig. 22.—THE FIRST, SIXTH, AND TWELFTH RIBS OF THE RIGHT SIDE. ⅛

A, the sixth seen from above and the outer side; B, the same rib viewed from below and within; C, the first rib viewed from above and without; D, the twelfth rib viewed from above and within.

1, the head in C & D, the ridge between the two facets of the head in B; 2, the neck; 3, the tubercle, in B presenting the rough tubercle and the smooth facet for articulation with the transverse process; 4, the lower border with the ridge and subcostal groove; 5, the upper border; 6, the oval pit for the attachment of the costal cartilage; 7, in the first rib, C, the scalene tubercle, and near it the smooth groove for the subclavian artery.

Inclination and Curves.—There is a general inclination of the ribs downwards from the head to the anterior extremity. This slope is greatest between the head and angle; beyond that point it is diminished, and it is again increased further forwards, and diminished at the anterior extremity. The curve of the ribs is much more marked towards the back part than in

front, and is most so in the neighbourhood of the angle. At first the rib is directed backwards as well as outwards. Besides the main curves now mentioned the rib is somewhat twisted on itself, so that the two extreme portions cannot be made to rest at the same time on a flat surface. It follows, from the same twisting in the majority of the ribs, that while their surfaces are vertical posteriorly, they are sloped upwards and inwards at the anterior part.

CHARACTERS PECULIAR TO CERTAIN RIBS.—The ribs increase in length from the first to the eighth, and decrease from the ninth to the twelfth, so that the last is little longer, often even shorter, than the first. The first rib is the broadest, and after it the middle ones; the twelfth is the narrowest. The distance of the angle from the tubercle increases gradually from the second to the eleventh; in the first the angle coincides with the tubercle, in the last it is not perceptible.

The *first* rib is shorter and broader than any of the others. Its direction is slightly inclined, and its surfaces lie nearly in the same flat plane. Its superficial and thoracic surfaces look respectively upwards and downwards. The head is small, and presents a single articular surface. The neck is round and slender. It articulates with the body and transverse process of the first dorsal vertebra alone. On the superior or superficial surface are two very slight smooth depressions with an intervening rough mark, and a considerable rough surface behind. The rough surface marks the attachment of the scalenus medius muscle, the posterior depression the position of the subclavian artery, the anterior depression the subclavian vein; and the intervening slight elevation, frequently terminating in a sharp spine on the inner edge, indicates the attachment of the scalenus anticus muscle.

The *second* rib is longer than the first, and presents externally a prominent roughness which marks the attachment of the serratus magnus.

The *eleventh* and *twelfth* are distinguished as the *free* or *floating* ribs, because their cartilages are pointed and unattached in front. They have no groove on the inferior border, no articular tubercle, and only one articulating surface on the head. The mark of the angle is scarcely perceptible on the eleventh, and is absent from the twelfth.

Varieties.—The number of the ribs is sometimes increased to thirteen on one or both sides. The supernumerary rib is most frequently very short, and is formed in connection with the transverse process of the first lumbar vertebra, or occasionally with the seventh cervical: in the latter case the additional rib has a double attachment, viz., to the body and transverse process of the vertebra. The number is sometimes diminished to eleven pairs by the absence of the twelfth. Ribs likewise occur greatly expanded or forked at their anterior extremities; and occasionally two or more ribs are united together in a part of their extent by their margins.

The COSTAL CARTILAGES are continuations of the ribs. Their breadth diminishes gradually from the first to the last, whilst the length increases as far as the seventh, after which it becomes gradually less. Their line of direction varies considerably. The first descends a little, the second is horizontal, and all the rest, except the last two, ascend more and more from the rib towards the sternum as they are situated lower down. The external or costal extremity, convex and uneven, is implanted into and united with the end of the corresponding rib. The internal extremities of the upper seven (except the first), are smaller than the external and somewhat pointed, and fit into the corresponding angular surfaces on the side of the sternum, with which they are articulated in synovial cavities. Each of the cartilages of the first three asternal ribs becomes slender towards its ex-

tremity, and is attached to the lower border of that which is next above it. The last two are pointed and unattached.

The first cartilage, which is directly united to the sternum without articular cavity, usually becomes more or less ossified in the adult male ; and the others likewise exhibit a considerable tendency to ossify in advanced life. This tendency is not so great in the female, in whom costal respiration is generally more extended than in the male.

THE THORAX AS A WHOLE.

The thorax is of a somewhat conical shape, with convex walls. Its upper inlet is contracted, and bounded by the first dorsal vertebra, the first pair of ribs, and the manubrium of the sternum. Its inferior margin curves downwards and backwards on each side from the ensiform process to the twelfth rib. Its longitudinal axis is directed upwards and slightly backwards. Its transverse diameter, at its widest part, greatly exceeds that from before backwards. The latter is shortened in the middle line by the projection of the vertebral column, but on each side of the column a considerable extension of the cavity is produced by the backward direction of the posterior parts of the ribs, and thus the weight of the body is thrown further back and more equally distributed round the vertebral column. At the same time a broad furrow is produced between the spines of the vertebræ and the angles of the ribs, in which are placed the erectores spinæ muscles.

Fig. 23.

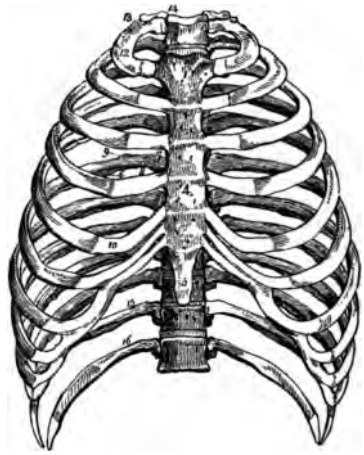


Fig. 23.—Front view of the Thorax, showing the Sternum Costal Cartilages, Ribs, and Dorsal Vertebræ. ½

1, the manubrium, or first piece of the sternum ; 2, is close to the place of union of the first costal cartilage ; 3, the clavicular notch ; 4, the middle of the body of the sternum ; 5, the ensiform piece ; 6, the groove on the lower border of the ribs ; 7, the vertebral end of the ribs ; 8, the neck ; 9, tubercle ; 10, costal cartilage ; 12, the first rib ; 13, its tuberosity ; 14, the first dorsal vertebra ; 15, the eleventh ; 16, the twelfth rib.

DEVELOPMENT OF THE RIBS AND STERNUM.

The first origin of the posterior parts of the ribs in connection with the primordial vertebræ has been already mentioned. In the second month cartilage appears in them, deposited independently of the vertebræ. Different opinions have been held as to whether the tubercle or the head of the rib is the primary point of its connection with the vertebra : it appears probable that the whole extent from head to tubercle is an expansion of the original connection. (Kölliker, "Entwicklungsgeschichte," fig. 81 ; Rathke, "Entwick. der Natter ;" Huxley, "On the Theory of the Vertebrate Skull," p. 74.) After becoming cartilaginous, the ribs pass round in the visceral wall, and, according to Rathke, before reaching the front, the first seven on

each side are united together at their anterior extremities in two longitudinal strips of cartilage, which afterwards join together in the middle line to form the sternum.

Fig. 24.

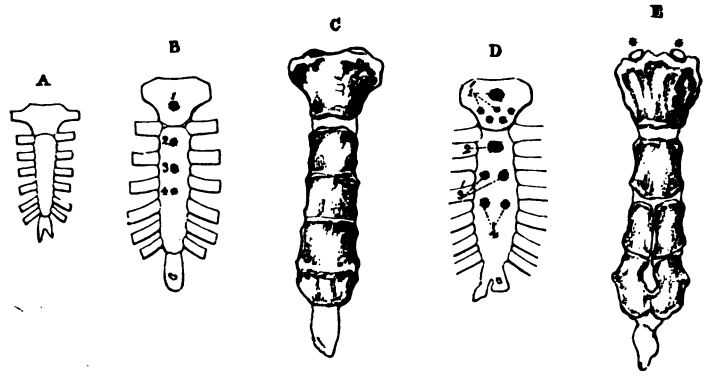


Fig. 24.—Ossification of the Sternum.

A, the cartilaginous sternum before the middle of fœtal life.

B, the sternum of a child at birth. 1, 2, 3, & 4, mark the commencing ossific nuclei for the manubrium and three upper pieces of the body.

C, the sternum soon after puberty, showing cartilage between the manubrium and body, and imperfect union of the first, second, and third pieces of the body, while the third and fourth are united.

D, shows an example of a sternum at birth with an unusual number of ossific centres, six in the manubrium, 1′, which is very uncommon; two pairs in the lower pieces of the body, 3′ & 4′, which is not unusual; 2, the single centre of the first piece of the body.

E, exhibits an example of the perforated sternum which probably depends upon the imperfect union of the pairs of ossific nuclei shown in D in the lower part of the body; this figure also shows two episternal bones or granules, * *.

Ossification.—Each of the ribs is ossified from one principal centre, and possesses two small epiphyses,—one belonging to the head, and, except in the last two ribs, another belonging to the tubercle.

The sternum is ossified in a number of separate pieces, one, at least, for each segment; the manubrium sometimes possesses two, placed one above

Fig. 25.

Fig. 25.—One of the Middle Ribs of a Person about eighteen or twenty years of age.

Showing, at 1, the principal piece or body; 2, the epiphysis of the head; 3, that of the tubercle.

the other, and has been found with a greater number. The third, fourth, and fifth segments, as well as the ensiform portion, are frequently formed each from two nuclei placed side by side, which may remain distinct for

a considerable time; the second segment has rarely more than one nucleus. Additional nuclei occasionally appear between some of the segments.

PERIODS OF OSSIFICATION OF THE RIBS AND STERNUM.

In the ribs—
The principal centres appear in the 7th or 8th week (fœtal life).
The epiphyses appear from the 16th to the 20th year.
The shaft and epiphyses unite about the 25th year.
In the sternum—
Ossification in the first segment appears in the 6th or 7th month (fœtal life).
Ossification in the second segment appears in the 7th or 8th month (fœtal life).
Ossification in the third and fourth segments appears shortly before birth.
Ossification in the fifth segments appears in the 1st year or later.
Ossification in the sixth or ensiform segment appears very variously from the 6th to the 15th year, or later.
The lower segments of the body unite after puberty.
The upper segments of the body unite from the 25th to the 30th year.
The body and ensiform segment generally unite in middle age.
The manubrium and body unite in old age.

THE BONES OF THE SKULL.

The skull is of a spheroidal figure, compressed on the sides, broader behind than before, and supported on the vertebral column. It is formed of a number of bones, all of which, with the exception of the lower jaw, are almost immovably united together by lines and narrow surfaces, more or less uneven, termed *sutures*. The skull is divided by anatomists into two parts, the cranium and the face. The cranium protects the brain; the face surrounds the mouth and nasal passages, and completes with the cranium the cavities for the eyes. The cranium is composed of eight bones, viz.: the *occipital*, two *parietal*, the *frontal*, two *temporal*, the *sphenoid*, and the *ethmoid*. The face is composed of fourteen bones, of which twelve are in pairs, viz.: the *superior maxillary*, *malar*, *nasal*, *palate*, *lachrymal*, and *inferior turbinated bones*; and two single, viz., the *vomer*, and the *inferior maxilla*.

THE OCCIPITAL BONE.

The occipital bone is situated at the lower and back part of the cranium. Its general form is that of a curved lozenge concave superiorly, through which, in its lower and anterior part, passes a large oval foramen, forming the communication between the cranium and spinal canal. The bone thus presents four borders and four angles, which receive names according to their position. The portion of the bone behind the foramen is *tabular*, that in front of the foramen forms a thick mass named *basilar* process, and the parts on the sides of the foramen, bearing the condyles or articulating processes by which the head is supported on the first vertebra, are distinguished as the *condyloid portions*.

The occipital bone articulates by its two superior borders with the parietal bones, and by its two inferior borders with the temporal bones, while the extremity of its basilar process is united to the body of the sphenoid, in the young condition by cartilage, but after the age of twenty years by continuous osseous* substance.

* Hence Sœmmerring described the occipital and sphenoid as a single bone under the name spheno-occipital, or basilar.

The TABULAR PORTION on its *posterior surface* presents a rough prominence, the *external occipital protuberance*, arching outwards from which, on each

Fig. 26.

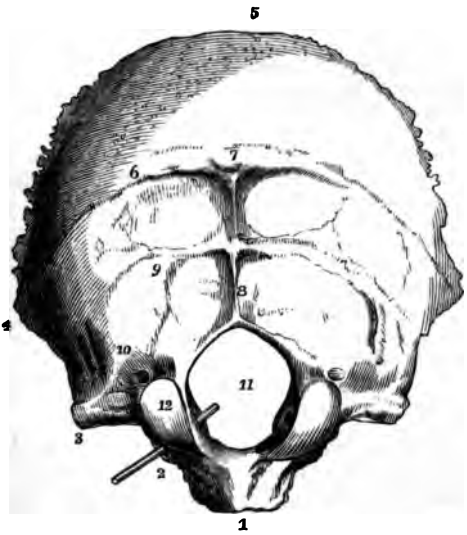


Fig. 26. — OCCIPITAL BONE FROM BELOW AND BEHIND, SHOWING THE EXTERNAL SURFACE. ½

1, basilar process; 2, condyloid portion, the probe marks the anterior condyloid foramen; 3, jugular or transverse process; 4, external or lateral angle; 5, superior angle; 6, superior curved line; 7, external or posterior occipital protuberance; 7, 8, external occipital crest; 9, inferior curved line; 10, groove and ridge connected with the attachment of the superior oblique muscle; 11, foramen magnum; 12, articular condyle; immediately above it the posterior condyloid foramen.

side, is the *superior occipital ridge* or *curved line*, which divides the surface into two parts, the upper, covered by the hairy scalp, convex and uniform; the lower, uneven and marked by the impressions of the muscles of the neck which are attached

Fig. 27.

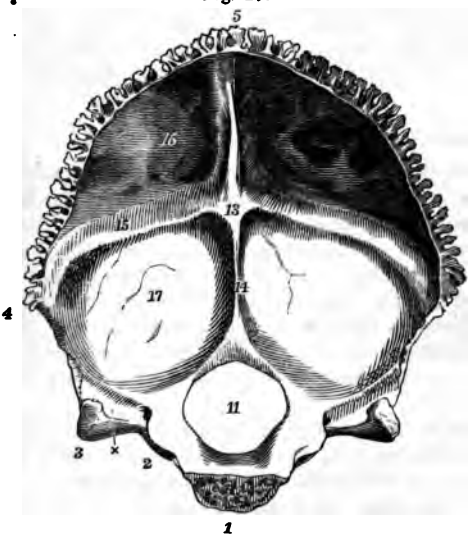


Fig. 27. — OCCIPITAL BONE FROM BEFORE, SHOWING THE INTERNAL SURFACE. ½

1, basilar process sawn through at the place of union with the sphenoid bone; 2, condyloid portion; 3, jugular or transverse process; ×, between 2 & 3, the sigmoid groove of the lateral sinus and jugular notch; 4, external or lateral angle; 5, superior angle; 1 to 3, the edge of articulation with the petrous bone; 3 to 4, with the mastoid bone; 4 to 5, with the parietal bone; 11, foramen magnum; 13, internal occipital protuberance and groove of the torcular Herophili; 14, inferior spine; 15, groove of the lateral sinus; from 5 to 13, groove of the superior longitudinal sinus; 16, cerebral fossa; 17, cerebellar fossa.

to it. This lower surface is divided into two lateral portions by a median ridge called the *external occipital crest* or *spine*, and each of these portions is again divided into

an upper and a lower surface by the *inferior curved line* or *ridge*, which, after extending some distance outwards, is met by a ridge and groove passing from before backwards. These surfaces mark the attachments of the rectus capitis major and minor, and of the obliquus capitis superior muscles.

The *deep surface* of the bone is marked by two crucial smooth ridges, one extending from the upper angle to the great foramen, and the other transversely from one lateral angle to the other, and at the point of intersection of these ridges is the *internal occipital protuberance*. Separated by these ridges are four hollows, the *superior* and *inferior occipital fossæ*, which lodge respectively the posterior cerebral and the cerebellar lobes. The superior and transverse ridges are grooved in the course of the longitudinal and lateral venous sinuses respectively. The space where those grooves meet at the internal occipital protuberance receives the torcular Herophili. The inferior ridge is single, and is named the internal occipital crest or spine. The margins of the tabular portion are deeply serrated above the lateral angles for articulation with the parietal bones, and, below that level, with the mastoid portions of the temporal bones.

The CONDYLOID PORTIONS bear the articulating condyles on their inferior surface, close to the margin of the foramen magnum. The condyles are so placed, that a line touching their posterior extremities would cross the middle of the foramen magnum. They are elliptical and placed obliquely so as to converge in front; their surfaces are convex from behind forwards and from side to side, and slightly everted. Their inner borders are rough, and receive the insertion of the odontoid ligaments of the axis. In front and to the inside of the condyles are the anterior condyloid foramina, which pass forwards and outwards from the interior of the cranium, and transmit the hypoglossal nerves. Behind the condyles are two pits, containing usually the posterior condyloid foramina; each of these gives passage to a vein; but they are often absent on one or both sides. Externally to the condyle, on each side, is a portion of bone, which is placed over the transverse process of the atlas, continuous posteriorly with the tabular part, and anteriorly having a free excavated margin, the *jugular notch*, which contributes with a fossa in the temporal bone to form the *foramen lacerum jugulare*; its external extremity projects into the angle between the mastoid and petrous portions of the temporal bone, and is called the *jugular eminence*. This process presents inferiorly a rough elevation, which gives attachment to the rectus capitis lateralis muscle; and superiorly a deep groove for the lateral sinus before it terminates in the jugular notch.

The BASILAR PROCESS projects forwards and upwards into the middle of the base of the skull. It increases in thickness and diminishes in breadth towards its extremity. Inferiorly it gives attachment to the rectus capitis anticus major and minor muscles and the fibrous band of the pharynx. Its superior surface presents a smooth depression, the basilar groove, which supports the medulla oblongata, and close to each lateral margin a slight grooved mark, which indicates the place of the inferior petrosal sinus.

Varieties.—The upper and lateral angles vary greatly in the degree of their acuteness. The upper borders are subject to considerable variation, from the presence of ossa triquetra. The condyles vary greatly in size, prominence, and convexity, and are often somewhat unsymmetrical. In some old subjects there is a mark at the back of the foramen magnum, where the occiput rests on the posterior arch of the atlas. Occasionally there is a projection downwards from the jugular process, resembling the descending lateral process found in most mammals.

THE PARIETAL BONE.

The parietal bones form a principal part of the roof of the skull. They have the shape of quadrilateral plates, convex externally, concave internally. They are a little broader above than below, and the anterior inferior angle is the most acute. They articulate with one another in the middle line, with the frontal bone anteriorly, the occipital posteriorly, and the temporal and sphenoid below.

Fig. 28.

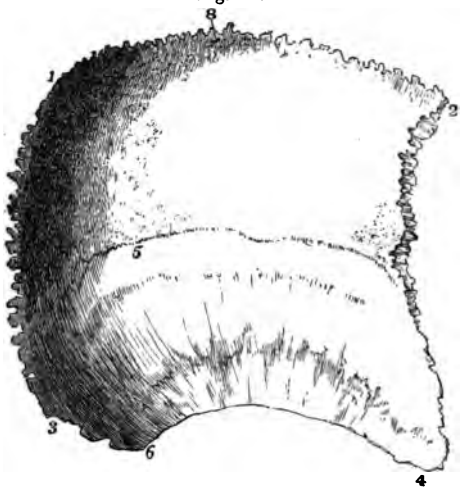


Fig. 28.—EXTERNAL SURFACE OF THE RIGHT PARIETAL BONE. ½

1. Posterior superior angle; 2, anterior superior angle; 3, posterior inferior angle; 4, anterior inferior angle; from 1 to 2, superior border in the sagittal suture; from 2 to 4, anterior border in the coronal suture; from 1 to 3, posterior border in the lambdoidal suture; from 4 to 6, the part of the inferior border in the squamous suture; from 3 to 6, the part in the additamentum suturæ squamosæ; 5, the temporal or semicircular line above which is the parietal eminence.

On the *outer surface*, the point of greatest convexity is called the *parietal eminence*. Below this a curved line is directed from the anterior to the lower part of the posterior margin; it is the parietal part of the temporal ridge, and bounds a surface somewhat flatter than the rest, *planum temporale*, which forms part of the temporal fossa. Near the posterior and upper angle, close to the middle line, there is often a small perforation of variable dimensions, the *parietal foramen*, which transmits a communicating vein.

Fig. 29.

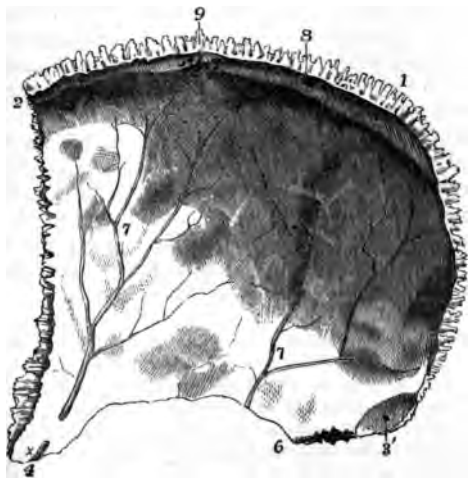


Fig. 29. — THE PARIETAL BONE FROM THE INSIDE. ½

1, 2, 3, 4, & 6 indicate the same parts as in the last figure: between 1 & 2 the half-groove of the superior longitudinal sinus; 7, the ramified grooves of the meningeal vessels; at x this groove is converted into a

canal, and throughout the inner surface the dimpling of the convolutions of the cerebrum; 8, the parietal foramen; 9, the irregular pits for the glandulæ Pacchionii.

On the *inner surface*, the hollow corresponding to the eminence is called the parietal fossa. This surface is marked by grooves branching upwards and backwards, corresponding with the course of the middle meningeal vessels, and by depressions corresponding with the convolutions of the brain. A slight depression along the superior border completes with the one of the opposite side a groove marking the course of the longitudinal sinus; and a depression at the posterior inferior angle forms a small part of the groove of the lateral sinus. Near the upper border there are in most skulls, but particularly in those of old persons, small irregular pits, *foveæ glandulares*, the result of absorption produced by the so-named glandulæ Pacchionii.

Borders.—The anterior, superior, and posterior borders are serrated. The inferior border presents in the greater part of its extent a sharp or squamous edge, with a slightly fluted surface directed outwards and overlapped at its anterior extremity by the great wing of the sphenoid, and behind that by the squamous part of the temporal bone; but at its posterior part it is serrated, and articulates with the mastoid portion of the temporal. The posterior border is the most deeply serrated. The anterior border is slightly overlapped by the frontal bone above, but overlaps the edge of that bone inferiorly.

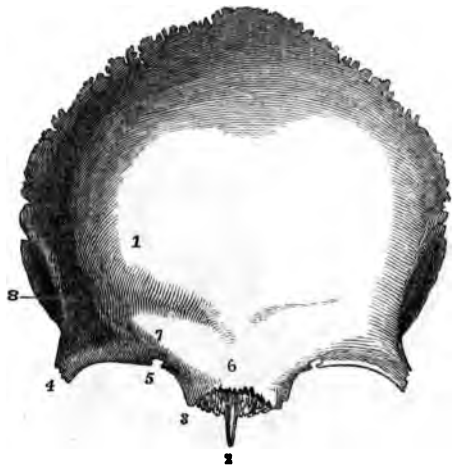
THE FRONTAL BONE.

The frontal bone, arching upwards and backwards from above the orbits, forms the fore part of the vault of the skull. It likewise presents inferiorly two thin horizontal laminæ, the *orbital plates*, which form the roofs of the orbits and are separated by a mesial excavation, the *incisura ethmoidalis*.

Fig. 30.—Frontal Bone from before, showing its External Surface. ½

1, frontal protuberance; 2, nasal spine, and above this the serrated surface for articulation of the nasal and superior maxillary bones; 3 to 4, supra-orbital edge —3, internal, and 4, external angular process; 5, supra-orbital notch or foramen; 6, glabella; 7, superciliary eminence and ridge; 8, temporal ridge, and behind this a part of the temporal fossa.

Fig. 30.



The frontal is articulated with twelve bones, viz., posteriorly with the parietals and sphenoid; outside the orbits with the malars; and between the orbits, from before backwards, with the nasal, superior maxillary, lachrymal and ethmoid bones.

Anterior Surface.—The part forming the greatest convexity of the forehead on each side is called the *frontal eminence*. It is separated by a slight depression below from the *superciliary ridge*, a curved elevation of

varying prominence immediately above the margin of the orbit. Between the superciliary ridges is the *nasal eminence* or *glabella*. The margin of the orbit, the *orbital arch*, is most defined towards its outer part; it presents towards its inner third the *supra-orbital notch*, sometimes converted into a foramen, which transmits the supra-orbital nerve and artery. The extremities of the orbital arch point downwards, and form the *internal* and *external angular processes*. The internal angular process is slender; the external is thick and strong, and articulates with the malar bone. The temporal ridge springs from the external aspect of this process, and arches upwards and backwards to be continued on the parietal bone: it separates the temporal from the frontal part of the outer surface of the bone.

Inferior Surface.—The orbital surfaces are somewhat triangular, their internal margins being parallel, while the external are directed backwards and inwards. Close to the external angular process is the *fossa lachrymalis*, which lodges the lachrymal gland; and close to the internal angular process is the *fovea trochlearis*, a small depression to which the pulley of the trochlearis muscle is attached. Between the orbits in front is the serrated surface which articulates with the superior maxillary and nasal bones, and in the middle line a sharp process of variable length, the *nasal spine*, descends between the latter bones and the central plate of the ethmoid. On the sides of the incisura ethmoidalis, the inner table of the bone extends nearer the middle line than the outer, and the intervening margin is thrown into shallow spaces, which form the roofs of cells in the ethmoid bone. Traversing this margin are two grooves, which complete, with the ethmoid, the *anterior* and *posterior internal orbital foramina*. The anterior groove transmits the nasal twig of the ophthalmic nerve and the anterior ethmoidal vessels; the other, the posterior ethmoidal vessels. Further forward, on each side of the nasal spine, is a larger hollow, the opening of the *frontal sinus*, which extends for a variable distance behind the superciliary ridges, and which communicates with the cavity of the nose. Outside the orbital surface behind the serrated border for the malar bone, there is a large serrated triangular area which articulates with the great wing of the sphenoid.

Fig. 31.

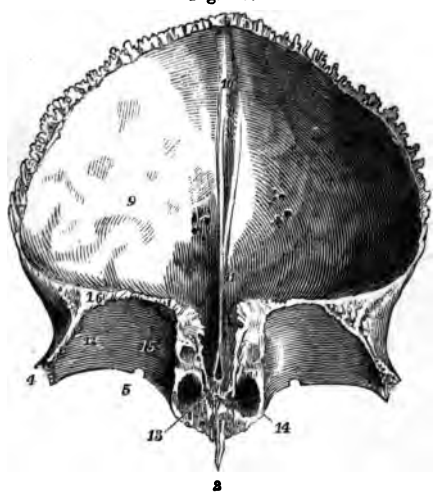


Fig. 31.—THE FRONTAL BONE FROM BEHIND AND BELOW, SHOWING THE INTERNAL CEREBRAL SURFACE AND THE ROOF OF THE ORBITS. ½

2, 4, and 5, as in the preceding figure; 9, internal or cerebral surface, slightly marked by cerebral convolutions and glandular pits; 10, groove of the superior longitudinal sinus, ending below in, 11, the internal frontal crest, which leads down to, 13, the foramen cæcum; 12, the orbital plate, the number is placed in the depression for the lachrymal gland; 14, the

opening of the frontal sinus; 15, placed near the inside of the roof of the orbit indicates the inner ends of the ethmoidal or internal orbital foramina.

Cerebral Surface.—This surface forms a large concavity, but the roofs of the orbital plates, which form its floor, are convex from side to side. It is covered with digitate impressions, which, with the intervening ridges, are strongly marked over the orbits. A groove, the *sulcus frontalis*, which lodges the commencement of the longitudinal sinus, ascends in the middle of the upper part of the bone; its margins approach inferiorly, and are elevated into a ridge, the *crista frontalis*. A small foramen, usually formed in part by the central plate of the ethmoid, is situated at its base; it is known as the *foramen cæcum*, but transmits a minute vein from the nasal fossæ. This surface is bounded posteriorly by a thin linear border, which articulates with the lesser wings of the sphenoid, and superiorly and laterally by a serrated border, which articulates with the parietals, and which, as has before been mentioned, slightly overlaps those bones above, and is overlapped by them at the sides.

THE TEMPORAL BONE.

The temporal bone (os temporis) takes part in the construction of the side and base of the skull, and contains in its interior the organ of hearing. It is usually described in three parts, viz., an expanded anterior and superior part the *squamous* portion, a much thicker posterior portion the *mastoid*, and below and between these the *petrous* portion, a three-sided pyramid exhibiting at its base externally the aperture of the ear and projecting forwards and inwards into the base of the skull.

It articulates posteriorly and internally with the occipital bone, superiorly with the parietal, anteriorly with the sphenoid and, by the zygomatic process, with the malar.

The SQUAMOUS PORTION extends forwards and upwards from its connection with the other portions, and presents superiorly an arched border which describes about two-thirds of a circle.

Fig. 32.

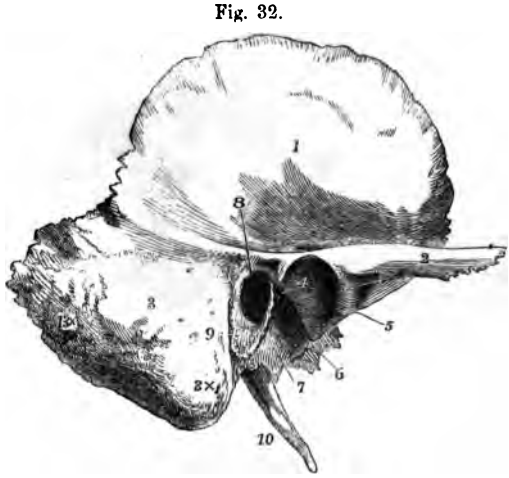


Fig. 32.—RIGHT TEMPORAL BONE FROM THE OUTSIDE. $\frac{2}{3}$

1, the external surface of the squamous part; 2, the zygoma; 3, the mastoid part; 8 ×, the mastoid process; 4, the articular part of the glenoid fossa; 5, the articular eminence at the root of the zygoma, and above it the tubercle; 6, fissure of Glaser; 7, the tympanic plate forming the posterior non-articular part of the glenoid fossa, terminating behind in the vaginal process; 8, the meatus auditorius externus; 9, the auditory process; 10, the styloid process; 13 ×, the mastoid foramen.

The *inner surface* is marked by cerebral impressions, and by meningeal grooves. At its upper border, the outer table is prolonged considerably

beyond the inner, forming a thin scale with the rough surface looking inwards and overlapping the corresponding bevelled edge of the parietal bone. But in front the border is thicker, looks directly forwards, and is serrated for articulation with the great wing of the sphenoid bone.

The *outer surface* is in its greatest extent vertical, with a slight convexity, and forms part of the temporal fossa. From its lowest part a long process, the zygoma, takes origin.

The *zygoma*, or zygomatic process, is at its base of considerable breadth, and projects outwards. It then becomes narrower, and is twisted on itself so as to present an outer and inner surface, and a sharp upper and lower border. The superior margin is the thinnest, and is prolonged furthest forwards. The bevelled extremity is serrated, and articulates with the malar bone. At its base the zygomatic process presents two roots. The *anterior* root is a broad convex ridge, directed inwards. The *posterior* root passes backwards, and is divided into two parts, of which one turns inwards in front of the meatus externus, while the other, gradually subsiding, is continued backwards over that opening, and marks behind it the line of union of the squamous and mastoid portions of the *bone*. At the point of division of the two roots is a slight *tubercle*, which gives attachment to the external lateral ligament of the lower jaw. Between them is the *glenoid fossa*, a depression elongated from without inwards, and which, together with a cylindrical elevation on the anterior root of the zygoma in front of it, is coated with cartilage, and forms the articular surface for the joint with the lower jaw. The fissure of Glaser separates this articular part of the glenoid fossa from the remaining part behind, which is formed by the tympanic plate of the petrous division of the temporal bone and lodges a portion of the parotid gland.

Fig. 33.

Fig. 33.—THE RIGHT TEMPORAL BONE FROM THE INNER SIDE. ⅔

The indications where marked are the same as in the preceding figure. 11, the inner or cerebral surface of the squamous portion; 11×, the squamous edge; 12, inner surface of the mastoid portion; 13, the sigmoid groove of the lateral sinus—the figure is placed at its upper part, and close to the mastoid foramen; 14, the apex of the petrous bone; 15, the meatus auditorius internus; 16, the shelf of bone covering the aqueduct of the vestibule; 17, is above the aqueduct of the cochlea; 18, the superior petrosal groove; 19, the eminence of the superior semicircular canal; 20, the hiatus Fallopii.

The MASTOID PORTION is rough externally for the attachment of muscles, and is prolonged downwards behind the aperture of the ear into a nipple-shaped projection—the *mastoid process*. This process forms the outer wall of a deep groove on its inner side, the *digastric fossa*, which gives attachment to the

digastric muscle; and internal to that is the slight *occipital groove*, for the occipital artery. The internal surface of the mastoid portion is marked by a deep sigmoid depression, descending in the angle between it and the petrous portion, which is part of the groove of the lateral sinus. A passage for a vein, of very variable size, the *mastoid foramen*, usually pierces the bone near its posterior margin, and opens into the groove.

Fig. 34.

Fig. 34.—The Right Temporal Bone from below. ⅔

The indications where marked are the same as in the preceding figures. 14, is at the apex of the petrous bone in the upper opening of the carotid canal; 21, lower rough surface of the petrous bone; 22, the lower opening of the carotid canal; 23, the small foramen of Jacobson's nerve; 24, the jugular depression, and within it, 25, the foramen of Arnold's nerve; 26, stylo-mastoid foramen—the figure is placed in the anterior part of the digastric groove; 27, groove of the occipital artery; 28, place of the anterior opening of the osseous Eustachian canal.

The petrous portion is named from its hardness. It contains the organ of hearing. It forms a three-sided pyramid, with its base directed outwards, one surface looking downwards, and the other two turned towards the interior of the skull.

Inferior surface, base and apex.—At the base is the aperture of the ear. It forms a short canal, the *meatus auditorius externus*, directed inwards and a little forwards, narrower in the middle than at its extremities, and leading into the cavity of the *tympanum*. It is bounded superiorly by the posterior root of the zygoma, and posteriorly in the remainder of its circumference chiefly by the *external auditory process*, a curved uneven border, to which the cartilage of the ear is attached. This process is the thickened outer extremity of the *tympanic plate*, a lamina one surface of which forms the anterior wall of the external auditory meatus and the tympanum, while the other looks forwards and downwards. The anterior margin of the tympanic plate is separated from the glenoid fossa by the *fissure of Glaser*, which communicates with the tympanum, while its posterior margin descends as a sharp edge, the *vaginal process*, which partly surrounds the front of the styloid process at its base. The *styloid process* is long and tapering, and is directed downwards and forwards. It is placed in front of the digastric fossa, and has immediately behind it the foramen which forms the outlet of the canal of the facial nerve, named *stylo-mastoid* from its position between the styloid and mastoid processes. A smooth rounded and deep depression, the *jugular fossa*, lies internal to the styloid process; it is close to the posterior margin of the bone, and completes with the jugular notch of the occipital bone the foramen lacerum posterius. In front and a little to the inside of the jugular fossa is the *carotid foramen*, the inferior extremity of the carotid canal; and internal to the carotid foramen is a rough surface which gives attachment to the levator palati muscle, and is continued into the rough inner extremity, or *apex* of the petrous bone. The *carotid canal* ascends at first perpendicularly, then turns horizontally forwards and inwards, and

emerges at the apex, close to the anterior margin. It transmits the internal carotid artery.

The *posterior surface* looks backwards and inwards, and forms part of the posterior fossa in the base of the skull. It presents a large orifice leading into a short canal which is directed outwards, the *meatus auditorius internus*. This canal is terminated by a lamella of bone, the *lamina cribrosa*, presenting in the lower part small apertures through which the fibrils of the auditory nerve pass, while in its upper part is the commencement of the canal called aqueduct of Fallopius, which transmits the facial nerve. The facial canal takes a somewhat circuitous course through the petrous bone, passing outwards and backwards over the labyrinth of the ear, and then downwards to terminate at the stylo-mastoid foramen.

The *anterior* or *upper surface*, looks upwards and forwards, and forms part of the middle fossa in the base of the skull. A depression over the apex marks the position of the Gasserian ganglion. A narrow groove runs obliquely backwards and outwards to a foramen named the *hiatus Fallopii*, which leads to the aqueduct of Fallopius; and lodges the large superficial petrosal nerve. Farther back is a rounded eminence, indicating the situation of the superior semicircular canal.

The *superior border* is grooved for the superior petrosal sinus. The *anterior border* is very short, and forms at its junction with the squamous part an angle in which is situated the orifice of the *Eustachian canal*, the osseous portion of a tube of the same name, which leads from the pharynx to the tympanum; and above this, partially separated from it by a thin lamella, the *processus cochleariformis*, a small passage which lodges the tensor tympani muscle. The *posterior border* articulates with the basilar process of the occipital bone, and bounds the foramen lacerum posterius.

Small foramina.—The opening of the *aqueductus vestibuli* is a narrow fissure covered by a depressed scale of bone, and situated on the posterior surface of the petrous bone, about three lines behind the internal auditory meatus; that of the *aqueductus cochleæ* is a small foramen, beginning in a three-sided wider depression in the posterior margin, directly below the internal auditory meatus. In the plate between the jugular fossa and the carotid canal is the foramen by which the nerve of Jacobson passes to the tympanum. In the ascending part of the carotid canal is the minute foramen for the tympanic branch of the carotid plexus. In the jugular fossa are a groove and foramen for the auricular branch of the vagus nerve; and parallel to the hiatus Fallopii, close to the canal for the tensor tympani muscle, are a groove and foramen for the small superficial petrosal nerve.

THE SPHENOID BONE.

The sphenoid, or wedge-shaped bone, is placed across the base of the skull, near its middle. It enters into the formation of the cavity of the cranium, the orbits, and the posterior nares. It is of very irregular shape, and consists of a central part or *body*, a pair of lateral expansions called the *great wings*, which form the largest part of the bone, a pair of much smaller horizontal processes in front, called the *small wings*, and a pair which project downwards, the *pterygoid processes*.

The sphenoid is articulated with all the seven other bones of the cranium and with five of those of the face, viz., posteriorly with the occipital and with the petrous portions of the temporals, anteriorly with the ethmoid frontal and malars, laterally with the squamous portion of the temporals, the parietals and frontals, and inferiorly with the vomer and palate bones.

The BODY.—*The superior surface* presents in the middle a deep pit, the *pituitary fossa, sella turcica,* or *ephippium,* which lodges the pituitary body. In front of the fossa, separated from it by a shallow transverse groove, is a narrow portion of bone on a level with the optic foramina, the *olivary process,* on which rests the commissure of the optic nerves; and in front of this is a surface on a slightly higher level, continuous with the superior surfaces of the small wings, and having a slight projection forwards of its anterior border, which articulates with the cribriform plate of the ethmoid, and is called the *ethmoidal spine.* Behind the pituitary fossa is a prominent lamella, the *dorsum sellæ,* the posterior surface of which is sloped upwards and forwards in continuation of the basilar groove of the occipital bone. The angles of this lamella project over the fossa, and are called the *posterior clinoid processes.* On each side of the body the surface descends obliquely to a considerably lower level than the fossa; it presents close to the margin of the fossa a superficial curved groove directed from behind forwards, marking the course of the internal carotid artery.

Fig 35.

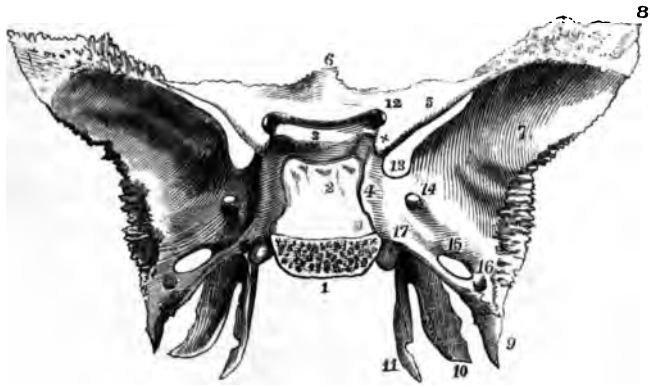


Fig. 35.—THE SPHENOID BONE FROM ABOVE AND BEHIND. ⅔

1, the basilar surface, sawn separate from the occipital bone; 2, inclined surface of the body terminating superiorly in the two posterior clinoid processes; 3, is placed on the olivary eminence or process, and between it and 2 is the sella turcica, or pituitary fossa; in front of 3 is the transverse groove of the optic commissure; 4, the side of the body with the sigmoid groove of the internal carotid artery and cavernous sinus; 5, the lesser wings; ×, the anterior clinoid process; 6, the ethmoid spine; 7, the cerebral surface of the greater wings; 8, the upper angle of the great wings, which articulates with the parietal bone; 9, the spinous process; 10, the external, and 11, the internal pterygoid process; 11, is placed opposite the hamular process and groove for the tendon of the tensor palati muscle; 12, the optic foramen; 13, the sphenoidal fissure or foramen lacerum orbitale; 14, the foramen rotundum; 15, the foramen ovale; 16, the foramen spinosum; 17, is placed above the posterior opening of the pterygoid or Vidian foramen.

The *posterior surface* is flat, and united to the basilar process of the occipital bone, in early life by cartilage, but in adult age by continuous bony substance.

Anterior and inferior surfaces.—Posteriorly, the body of the sphenoid is solid, but anteriorly and inferiorly it contains two large cavities, the *sphenoidal sinuses,* separated by a thin mesial lamina, the *sphenoidal septum,* and covered in front and below by the *sphenoidal spongy bones.* A prominent spine, called the *rostrum,* formed partly by the septum, partly by the

spongy bones, dips forwards and downwards, and is connected with the vomer. A thin edge, the *sphenoidal crest*, extends from the rostrum to the ethmoidal spine, and articulates with the central plate of the ethmoid.

The *sphenoidal spongy bones, cornua sphenoidalia*, or *bones of Bertin*, are a pair of thin curved plates, whose closest anatomical relationship in the adult is with the sphenoid bone, but which are originally distinct, and are frequently united by earlier or stronger anchylosis with the ethmoid or palate bones, so as to adhere, at least in part, to either of these in disarticulation of the skull, and thus to lay open the sinuses of the sphenoid. The anterior part of each looks forwards, and leaves a considerable round opening by which the sinus communicates with the nasal cavity; the lower and posterior part is of a triangular form, with the apex directed backwards.

At the anterior and outer angle of the sphenoidal spongy bone is a small part which enters into the formation of the inner wall of the orbit, articulating in front with the ethmoid, behind with the sphenoid, above by a small angle with the frontal, and below with the orbital process of the palate bone. It is most frequently fused in the adult with the sphenoid or ethmoid, often, however, with the palate bone only, and sometimes it remains free. (See Cleland in Trans. of Roy. Soc. for 1862.)

The GREAT WINGS, *alæ majores*, project outwards and upwards from the sides of the body. The lower and back part of each, horizontal in direction, occupies the angle between the petrous and squamous portions of the temporal bone; from its pointed extremity it sends downwards a short and sharp projection, the *spinous process*. The upper and fore part is vertical, and three-sided, lying between the cranial cavity, the orbit, and the temporal fossa. The *cerebral surface* of the great wing is concave, and forms part of the middle fossa of the base of the cranium. The *external surface* (temporozygomatic) is divided by a ridge into an inferior part, which looks downwards into the zygomatic fossa, and an elongated superior part, looking outwards, which forms a part of the temporal fossa. The *anterior surface* looks forwards and inwards, and consists of a quadrilateral *orbital* portion, which forms the back part of the external wall of the orbit, and of a smaller inferior portion which overhangs the pterygoid process, looks into the sphenomaxillary fossa, and is perforated by the foramen rotundum. Posteriorly, the cerebral and external surfaces are separated by the margins which articulate with the temporal and parietal bones; anteriorly, the superior divisions of the external and anterior surfaces are separated by the margin which articulates with the malar bone, while their inferior divisions come into contact with each other, and form the upper part of the posterior boundary of the pterygo-maxillary fissure; internally, the cerebral and orbital surfaces come into contact at the outer border of the sphenoidal fissure; and superiorly, all three surfaces abut against the triangular area which articulates with the frontal bone.

The SMALL WINGS, *alæ minores*, or *wings of Ingrassias*, extend nearly horizontally outwards from the fore part of the superior surface of the body. The extremity of each is slender and pointed, and comes very close to, but not into actual contact with the great wing. The superior surface forms part of the anterior fossa of the base of the cranium, the inferior overhangs the sphenoidal fissure and the back of the orbit. The anterior border, thin and serrated, passes directly outwards, and articulates with the orbital plate of the frontal bone. The posterior border is prominent and free, and forms the boundary between the anterior and middle cranial fossæ: it is pierced at its base by the optic foramen, and immediately beyond that projects

backwards, making a smooth rounded knob, the *anterior clinoid process*, which inclines towards the posterior process of the same name, and is grooved on its inner margin for the internal carotid artery.

The PTERYGOID PROCESSES project downwards and slightly forwards, between the body and the great wings. Each consists of two plates united in front and diverging behind, so as to enclose between them the *pterygoid fossa*. The *external pterygoid plate* lies in a plane extending backwards and outwards; its outer surface bounds the zygomatic fossa, and gives attachment to the external pterygoid muscle. The *internal pterygoid plate* is longer and narrower than the external, and is prolonged into a slender process turned outwards and named the hook-like or *hamular process*, round which in a groove plays the tendon of the tensor palati muscle. At its base, the internal plate turns inwards beneath the body, from which its extremity remains distinct as a slightly raised edge, which articulates with the margin of the vomer; and external to this it is marked by a small groove, which contributes with the palate bone to form the *pterygo-palatine canal*. The walls of the pterygoid fossa are incomplete at the lower part in the disarticulated sphenoid bone, an angular interstice existing between the plates, which, in the articulated skull, is occupied by the pyramidal process of the palate bone. In this fossa arises the internal pterygoid muscle, and at its base is a slight depression, distinguished as the *navicular fossa*, which gives attachment to the tensor palati muscle.

Fig. 36.

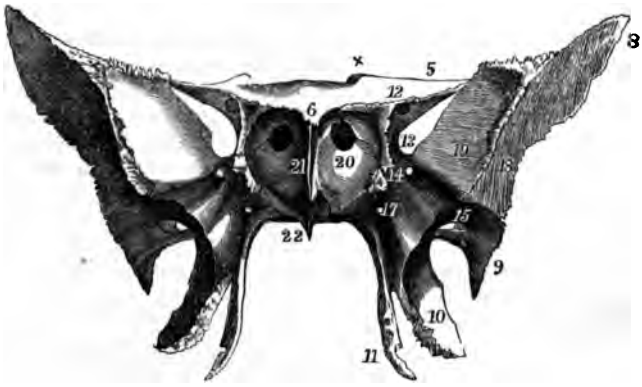


Fig. 36.—THE SPHENOID BONE FROM BEFORE. ⅔

The indications where marked are the same as in the preceding figure. 17, marks the anterior opening of the Vidian foramen or canal; 18, the external or temporal surface of the great wing; 19, its orbital surface; 20, the sphenoidal turbinated or spongy bone; above 20, the opening into the sphenoidal sinus; 21, the sphenoidal spine; 22, the rostrum, and above 22, the inverted laminæ, which fit with the edges of the vomer.

FISSURES and FORAMINA.—Each lateral half of the bone presents a fissure, four foramina, and a canal. The *sphenoidal fissure* is the obliquely placed elongated interval between the great and small wing; it is closed externally by the frontal bone, so as to form the *foramen lacerum orbitale*; it opens into the orbit, and transmits the third, fourth and sixth nerves, the ophthalmic division of the fifth nerve, and the ophthalmic vein. Above and to the inside of it is the *optic foramen*, which is inclined outwards and forwards from the side of the olivary process, pierces the base of the small

wing, and transmits the optic nerve and the ophthalmic artery. The *foramen rotundum* is directed forwards through the great wing, below the sphenoidal fissure; it opens immediately below the level of the orbit, and transmits the superior maxillary division of the fifth nerve. The *foramen ovale* is a large foramen, external and posterior to the foramen rotundum, situated near the posterior margin of the great wing, and directed downwards; it transmits the inferior maxillary division of the fifth nerve. The *foramen spinosum* is a small foramen immediately external and posterior to the foramen ovale; it pierces the posterior angle of the great wing, and transmits the middle meningeal vessels.

The *Vidian*, or *Pterygoid canal*, passes through the bone horizontally from before backwards at the base of the internal pterygoid plate; it opens anteriorly into the spheno-maxillary fossa, and posteriorly into the foramen lacerum medium, and transmits the Vidian nerve and vessels.

Varieties.—The groove of the internal carotid artery on the inner aspect of the anterior clinoid process is frequently converted into a foramen by a spiculum of bone stretching outwards to that process from the side of the pituitary fossa, and forming what has been called the *middle clinoid process;* and in cases where this occurs another spiculum is sometimes found, uniting the anterior and posterior clinoid processes. In many cases a third spiculum, the *lingula* (Henle), projects backwards from the posterior extremity of the carotid groove outside the artery. A bridge of bone, or of ligament, sometimes passes from the margin, and sometimes from the extremity of the external pterygoid plate to the spinous process. The foramen ovale and foramen spinosum are frequently open behind.

ETHMOID BONE.

The ethmoid, or sieve-like bone, projects downwards from between the orbital plates of the frontal bone, and enters into the formation of the cranium, the orbits, and the nasal fossæ. It is of a cuboid figure. It is exceedingly light for its size, being composed of very thin plates of bone and a collection of irregular cells. It consists of a *central vertical plate*, and of *two lateral masses*, united at their superior extremities by a horizontal *cribriform lamella*.

Fig. 37.

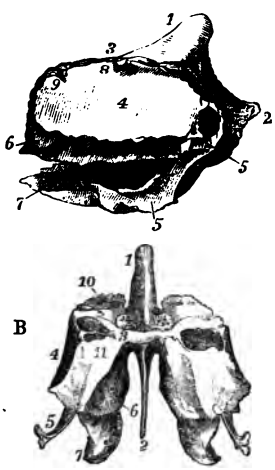


Fig. 37.—The Ethmoid Bone. ⅔

A, from the right side. 1, crista galli; 2, vertical plate; 3, cribriform plate and foramina; 4, orbital plate or os planum; 5 5, the uncinate process; 6, the superior, and 7, the inferior turbinated bone; 8, the anterior, and 9, the posterior ethmoidal groove or foramen.

B, the ethmoid bone from behind. The indications where marked are the same as in A. 10, the lateral or cellular part of the bone; 11, its posterior surface of union with the sphenoidal turbinated and palate bones.

It articulates with thirteen bones: the frontal, sphenoid and vomer, the nasal, lachrymal, superior maxillary, palatal, and inferior turbinated bones.

The CENTRAL PLATE lies in the mesial plane, and forms the upper part of the septum of the nose. Its superior margin appears in the cranial cavity, above the cribriform lamella, in the form of a ridge which rises anteriorly into a thick process, the *crista galli*, to which the falx cerebri is attached.

The anterior margin of the crista galli is vertical and broad, usually presenting a groove, which completes the foramen cæcum of the frontal bone. Below the level of the cribriform lamella, the anterior margin of the central plate articulates with the nasal process of the frontal and with the nasal bones. The inferior margin articulates in front, and sometimes even in its whole extent, with the septal cartilage of the nose; and in its posterior half, in the adult, is more or less completely joined by osseous union on one or both sides to the two plates or alæ of the vomer. The posterior margin is very thin, and is united to the sphenoidal crest of the sphenoid. This plate presents a number of grooves and minute canals leading from the foramina of the cribriform lamella, for the transmission of the olfactory nerves.

The LATERAL MASSES enclose a number of spaces of irregular form, the *ethmoidal cells*, which in the recent state are lined with prolongations of the mucous membrane of the nose. On the *external aspect* of each lateral mass is a thin, smooth lamina, of a quadrilateral form, the *orbital plate* or *os planum*, which closes in the ethmoidal cells, and forms a considerable part of the inner wall of the orbit. The orbital plate articulates in front with the lachrymal, behind with the sphenoid, above with the frontal, and below with the orbital surfaces of the superior maxillary and palate bones. In front of the orbital plate the lateral mass extends forwards, under cover of the lachrymal bone; and from this part descends the *uncinate* or *cuneiform* process, a long thin lamella which curves downwards, outwards, and backwards, forming part of the inner wall of the maxillary antrum, and articulating at its extremity with the inferior turbinated bone. (See fig. 50.)

The *internal aspect* forms part of the external wall of the nasal fossa, and consists of a thin, uneven, osseous plate, connected above with the cribriform lamella, and exhibiting a number of canals and grooves for branches of the olfactory nerve. It is divided at its back part by a channel, directed upwards and forwards from its posterior margin to about its middle. This is called the *superior meatus of the nose*, and communicates with the posterior ethmoidal cells. The short margin which overhangs this channel constitutes the *superior turbinated process* or *spongy bone*. Below this is a slightly folded margin of much greater extent, and free in front, the *inferior turbinated process* or *middle spongy bone*, which overhangs the *middle meatus of the nose*. From the front of the middle meatus a passage, the *infundibulum*, is prolonged upwards and forwards through the anterior ethmoidal cells, and opens into the frontal sinus. (See also fig. 54.)

In the separate ethmoid bone the cells are open posteriorly and superiorly, but when the bone is in connection with the rest of the cranium these cells are closed, above by the frontal bone, and behind by the sphenoidal spongy bones. In the superior margin are two grooves, which complete with the frontal bone the internal orbital foramina.

The CRIBRIFORM LAMELLA corresponds in size to the incisura ethmoidalis of the frontal bone which it occupies. At the sides of the crista it is depressed into two grooves which lodge the olfactory bulbs; and it is pierced by numerous foramina for transmission of the filaments of the olfactory nerves. The foramina, which lie along the middle of each groove, are simple perforations; the internal and external sets are longer, and are the orifices of small canals which subdivide as they descend on the central plate and lateral masses. At the anterior extremity is a small fissure at each side of the crista galli, close to its base, and external to this a foramen, connected usually by a slight groove with the anterior internal orbital foramen, which transmits the nasal branch of the ophthalmic nerve.

THE SUPERIOR MAXILLARY BONE.

This, the upper jaw, is one of the principal bones of the face; it supports all the teeth of the upper range, and takes part in the formation of the hard palate, the floor of the orbit, and the floor and lateral wall of the nasal cavity. It presents inferiorly a thick ridge, the alveolar process perforated with the sockets for the roots of the teeth, and a horizontal palate plate; externally, a convex surface corresponding with the anterior and lateral parts of the face; superiorly, an ascending or nasal process and an orbital plate; and internally, a nasal surface, opening from which is a large cavity or sinus, hollowed out beneath the orbital plate in the body of the bone. The superior maxillary bone articulates with its fellow, with the nasal, frontal, lachrymal, ethmoid, palate, malar, vomer, and inferior turbinated bones, and with the nasal cartilages.

Fig. 38.

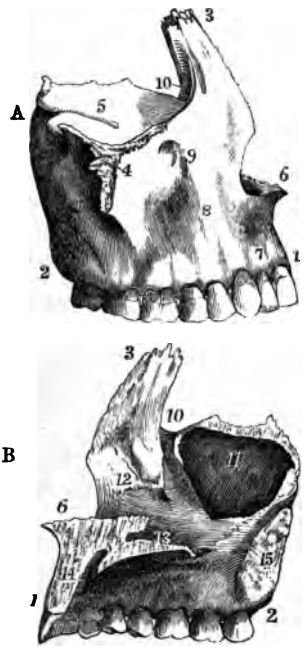


Fig. 38.—Superior Maxillary Bone of the Right Side. ½

A, from the outside; B, from the inside.

1 to 2, alveolar process or arch—1 at the middle incisor tooth, 2 marks the tuberosity, and above it, in A, the posterior dental foramina; 3, the nasal or ascending process; 4, malar tuberosity or process; 5, orbital plate or process; 6, placed in the nasal notch marks the nasal crest terminating in the nasal spine; 7, the incisor or myrtiform fossa; 8, is in front of the canine fossa; 9, the infra-orbital foramen, and below 5, the infra-orbital groove and canal; 10, groove of the nasal or lachrymal duct; 11, antrum maxillare, or maxillary sinus; 12, on the inner surface of the nasal process, marks the oblique ridge for the attachment of the inferior turbinated bone; 13, is placed above the palate-plate; from 13 to 6, the vomeric and septal crest; from 13 to 14, the incisor foramen; 15, placed on the surface of articulation of the body with the palate-bone, points to the posterior palatine or palato-maxillary canal. These figures also exhibit a full set of the upper teeth of one side as they occur in middle life, little worn by use.

The *alveolar border* or process, thick and arched, is hollowed out into sockets or *alveoli*, corresponding in number, form, and depth to the roots of the teeth, which are fixed in them.

The *palate plate*, along with that of the opposite side, forms about three-fourths of the hard palate. Its superior surface is smooth and concave from side to side; its inferior surface is vaulted and rough, and is marked laterally with grooves for nerves and vessels, which reach the palate through the posterior palatine canal. Its posterior extremity falls short of that of the alveolar arch and body of the bone, and articulates with the horizontal process of the palate bone, which completes the hard palate. The mesial border rises into a serrated vertical ridge, upon which the vomer rests. This border, or ridge, is interrupted at its anterior part by a canal, the *incisor foramen*, which is completed on its mesial side by a slender lamina

directed backwards from the anterior to the posterior border, from the latter of which, however, in young bones the lamina remains disconnected. In front of this canal the mesial border of the bone rises to a considerably greater height than behind it, forming, with its neighbour, the *nasal crest*—a grooved elevation which supports the extremity of the vomer and the septal cartilage, and is prolonged forwards into the *nasal spine*. Each incisor foramen widens out below into a larger hollow, which, when placed in apposition with its fellow, completes a mesial aperture, the *anterior palatine foramen*. Viewed from below, this aperture may be seen to be divided into four smaller foramina, two of which placed laterally are the incisor foramina, called also *foramina of Stenson*, while the other two, placed in the middle line, one before the other, are distinguished as the *foramina of Scarpa*. The whole communication between the nose and the palate may be designated collectively as the *anterior palatine canal*.

The terms *incisor foramen* and *anterior palatine canal* are often used convertibly and vaguely to express what has been above defined as the anterior palatine canal, or its inferior opening. According to the definitions here given, *incisor foramen* has the same meaning in human as in comparative anatomy, while anterior palatine canal is restricted to an appearance which presents itself only in man and a few animals. The lamina passing backwards from before each incisor foramen corresponds to the mesial palatine process of the intermaxillary bone in other animals, *e. g.*, the carnivora: while the incisor foramina are those which are seen largely developed in those animals, and are the remains of a primitive communication between the nose and mouth. The foramina of Scarpa lie in the suture between the laminæ referred to. They transmit the naso-palatine nerves; the nerve of the right side occupying, according to Scarpa, the posterior one, which is usually largest, and that of the left side the anterior: but they are very inconstant. (Scarpa, Annot. Anatom., lib. ii. cap. 5.)

Fig. 39.—Front Part of the Palate and Alveolar Arch of an Adult, ⅔

Showing the lower opening of the anterior palatine or incisor foramen. 1, 2, are placed on the palate plates of the two superior maxillary bones; 4, anterior palatine foramen, in which is seen a partial division into four openings—the two lateral, with lines pointing to them from 1 and 2, are the incisor foramina (foramina of Stenson); the anterior and posterior, indicated by 3 and 4, are the naso-palatine, or foramina of Scarpa.

Fig. 39.

The *external surface* is divided into an anterior and a posterior part by the *malar process*, a prominence presenting a large triangular roughness for articulation with the malar bone, which abuts by its upper border against the edge of the orbital surface, and at its inferior angle projects outwards and downwards above the first molar tooth. The anterior portion is excavated in a smooth curved notch at its internal margin for the opening of the anterior nares. It is marked by a prominence corresponding to the position of the fang of the canine tooth; and internal to this is a slight depression, the *incisor* or *myrtiform fossa*; while between it and the malar process is the much deeper *canine fossa*, in which arise the levator anguli oris and compressor nasi muscles. Above the canine fossa, immediately below the margin of the orbit, is the *infra-orbital foramen*, which transmits the superior maxillary nerve. The posterior portion looks partly into the zygomatic, partly into the pterygo-maxillary fossa. It exhibits a convexity, the *tuberosity*, which projects backwards, and is perforated by a number of foramina transmitting the superior dental nerves and arteries.

The *ascending* or *nasal process* projects upwards from the anterior and internal part of the bone. Its surfaces are continuous with the external and internal surfaces of the bone ; its internal surface, towards its summit, is rough for articulation with the lateral mass of the ethmoid ; its anterior border is rough for articulation with the nasal bone, and its summit serrated for articulation with the frontal. Posteriorly, it articulates by a linear edge with the lachrymal bone ; and external to this it presents a well-marked groove for the lachrymal sac, the *lachrymal groove*, which is continued downwards on the inner surface of the bone, between this process and the orbital plate, and is converted into a canal by the lachrymal and inferior turbinated bones.

The *orbital surface* passes forwards to the margin of the orbit, and backwards to the spheno-maxillary fissure, and is bounded externally by the surface for the malar bone, and internally by the lachrymal groove and a rough edge which articulates with the lachrymal, ethmoid, and palate bones. It is interrupted by a groove which commences in its posterior border, and leads forwards into a complete canal, the *infra-orbital*, of which the infra-orbital foramen is the anterior termination. At the inner and fore-part of the orbital surface is a minute depression, which gives origin to the inferior oblique muscle of the eye.

The *nasal surface* presents an oblique rough line beneath the ascending process, for articulation with the inferior turbinated bone, and behind that process the lachrymal groove. Behind the lachrymal groove is the large opening into the sinus ; below and behind the sinus the surface is rough for articulation with the palate bone ; and traversing the lower part of this roughness is a smoother groove, passing downwards and forwards from the posterior margin, and completing with the palate bone the posterior palatine canal.

The *maxillary sinus*, or *antrum of Highmore*, is a large cavity lying above the molar teeth and below the orbital plate, lined in the fresh state by mucous membrane, and communicating with the middle meatus of the nose. Its orifice is considerably diminished by contiguous bones, viz., by the uncinate process of the ethmoid, the inferior turbinated bone, and the palate bone.

THE PALATE BONE.

The palatal or palate bone forms the back part of the palate, and the lateral wall of the nose between the superior maxillary bone and the internal pterygoid process. In form it has a general resemblance to the letter L, consisting of a horizontal and a vertical plate and three processes, viz., the pyramidal process, extending outwards and backwards from the junction of the horizontal and vertical plates, and the orbital and sphenoidal processes, surmounting the vertical plate.

The palate bone articulates with its fellow, and with the superior maxillary, ethmoid, sphenoid, vomer, and inferior turbinated bone.

The *horizontal* or *palate plate* presents posteriorly a thin free border, forming the limit of the hard palate, and giving attachment to the soft palate or velum ; anteriorly it articulates with the palate plate of the superior maxillary bone, and internally by a thick serrated border with its fellow of the opposite side, forming with it a ridge for articulation with the vomer, continuous with that of the superior maxillaries ; externally, at its junction with the vertical plate, it is grooved by the extremity of the posterior palatine canal. Its superior surface is smooth, and forms the back

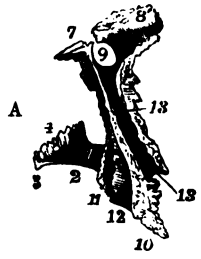
part of the floor of the nasal cavity; its inferior surface is rough, and is marked near its posterior border by a transverse ridge passing inwards from the base of the pyramidal process, giving attachment to the tendinous fibres of the tensor palati muscle.

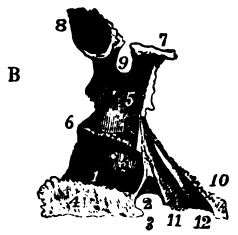
Fig. 40.—The Palate Bone of the Right Side. ⅔

A, from the outside and behind; B, from the inside.

1, the upper surface of the palatine plate; 2, its posterior curved border or palatine arch; 3, posterior nasal or palatine spine; 4, the rough surface of adjacent articulation rising superiorly into the vomeric crest, as in A; 5 5, the nasal process; 6, the ridge or shelf supporting the inferior turbinated bone; 7, the sphenoidal process; 8, in B, the orbital process, showing a cellular cavity; 8′, in A, its orbital surface; 9, the sphenopalatine notch; 10, 11, 12, the pyramidal process—10, rough surface of union with the external pterygoid plate, 11, with the internal ditto, and 12, the interpterygoid smooth surface; 13 13, palato-maxillary or posterior palatine canal.

Fig. 40.





The *vertical plate* is very thin. Its *internal surface* looks towards the nasal cavity, and is divided into two parts, corresponding to the middle and inferior meatus of the nose, by a nearly horizontal ridge which articulates with the inferior turbinated bone. The *external surface* is traversed by a smooth impression, directed downwards and slightly forwards, the upper part of which forms the internal wall of the spheno-maxillary fossa, while the lower part is hollowed into a deep groove, completing with the superior maxillary the *posterior palatine canal*, which transmits the large descending palatine nerve and accompanying vessels. In front of this canal the external surface is in contact with the internal surface of the maxillary bone and the side of the antrum; behind the canal it articulates inferiorly with the hinder border of the maxillary, superiorly with the inner surface of the pterygoid process.

The *pyramidal process* or *tuberosity* fits into the cleft between the pterygoid plates. It presents posteriorly a triangular surface which is smooth and grooved, and completes the pterygoid fossa on its sides; it is rough for articulation with the borders of the pterygoid plates. Inferiorly, close to its connection with the horizontal plate, are two small foramina, the *posterior* and *external small palatine* foramina, the extremities of two minute canals which transmit the smaller palatine nerves; the external one is smallest and inconstant.

The *orbital process* surmounts the anterior margin of the vertical plate. It has the general appearance of an inverted pyramid, and has five surfaces, two of which, the superior and external, are free, and the rest articulated. The superior surface forms the posterior angle of the floor of the orbit; the external looks into the spheno-maxillary fossa, the anterior articulates with the maxillary, the internal with the ethmoid, and the posterior, which is small and only exists towards the extremity of the process, articulates with the sphenoidal spongy bone.

The orbital surface is frequently found enlarged, extending upwards between the

ethmoid and sphenoid as far as the frontal bone. This condition results from the union with the palate bone of a separate centre of ossification, more usually united with the ethmoid or sphenoid, and already described with the sphenoidal spongy bone (p. 40).

The *sphenoidal process* curves upwards, inwards, and backwards from the posterior part of the vertical plate. Its superior or external surface is in contact with the sphenoidal spongy bone and the base of the internal pterygoid plate, and is grooved for the completion of the pterygo-palatine canal; its internal or under surface looks to the posterior nares; and at its base a third surface looks forwards and outwards into the spheno-maxillary fossa. Its inner extremity is in contact with the wing of the vomer.

The *spheno-palatine* foramen is formed in greatest part by the deep notch between the orbital and sphenoidal processes, and is completed above by the sphenoidal spongy bone. It leads from the spheno-maxillary fossa into the nasal cavity, and transmits the internal nerves from Meckel's ganglion and the nasal branch of the internal maxillary artery.

THE VOMER.

The vomer is a thin mesial bone, irregularly quadrilateral, and placed vertically between the nasal fossæ. It articulates with the sphenoid, ethmoid, palate, and maxillary bones, and with the septal cartilage of the nose. As it usually becomes united by anchylosis, at an early age, to other bones, and is frequently more or less absorbed and even distorted in some of its parts, it can be studied as a separate bone in certain specimens only.

Fig. 41.

Fig. 41.—The Vomer. $\frac{2}{3}$

A, from the right side; B, from above.

1 1', the upper everted edges on each side of the hollow which receives the rostrum of the sphenoid; 2, the anterior or ethmoid border, grooved to receive the septal cartilage of the nose, and prolonged at × into a process which rests upon the nasal crest; 3, the posterior or free border; 4, the inferior or maxillary and palatine border.

The part of the vomer which lies below the diagonal line extending from its posterior to its anterior extremity is a thin *mesial plate*, that which lies above this line consists of two *alæ*, rising on each side of a mesial groove, in which lies the septal cartilage of the nose. The alæ posteriorly are thick and expanded, and form the bifid posterior extremity of the bone, which rests beneath the sphenoid. The superior border of each ala, extending forwards from that point, articulates edge to edge with the lamella projecting at the base of the internal pterygoid plate, the sphenoidal process of the palate bone, and the extremity of the rostrum of the sphenoid; the anterior border, sloping downwards and forwards, in contact with the septal cartilage, is free in the inferior part, and is united superiorly by anchylosis on one or both sides with the central plate of the ethmoid. The anterior extremity of the vomer forms a short vertical line which fits in behind the nasal crest of the maxillaries, and from the upper end of which a process projects forwards in the groove

of the crest, while from its lower end a point projects downwards between the incisor foramina. The inferior border articulates with the ridge or crest which rises from the palate plates of the maxillary and palate bones. The posterior border, thin, smooth, and unattached, separates the posterior nares.

THE MALAR BONE.

The malar bone forms the most prominent part of the cheek, and, by a deep plate, divides the orbit from the temporal fossa. It articulates by a broad serrated surface near its anterior inferior angle with the malar process of the superior maxillary bone, by a slenderer posterior process with the zygoma, by a superior process with the frontal, and, continuously with that, by the margin of its deep plate with the great wing of the sphenoid bone. Between its sphenoidal and maxillary articulations a small portion of free margin generally intervenes, which closes the anterior extremity of the spheno-maxillary fissure. The facial surface is convex, and pierced by one or more *malar foramina*, which pass through from the orbital surface and transmit a small nerve and vessels. The orbital surface is concave from above downwards, and enters into the formation of the outer wall and floor of the orbit. The posterior surface is concave from side to side, and looks into the temporal and zygomatic fossæ; it is also pierced by a small foramen.

Fig. 42.

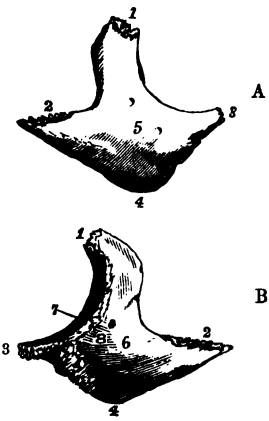


Fig. 42.—Right Malar Bone. ⅔

A, from the outside; B, from the inside.

1, superior or frontal angle and serrated edge; 2, posterior or external angle and serrated surface for the zygoma; 3, anterior or internal angle; 4, inferior angle; from 1 to 2, the temporal border; from 1 to 3, the orbital border; from 1 to 8, edge of articulation with the frontal and sphenoid bones; at 8, the notch terminating generally the spheno-maxillary fissure; from 2 to 4, the masseteric rough border; between 8, 3, and 4, the triangular serrated surface for articulation of the superior maxillary bone; 5, the external surface; 6, the deep or posterior surface; 5 and 6, near the foramina for the temporo-malar nerves; 7, the orbital surface, with the orbito-malar foramen.

THE NASAL BONE.

The nasal bones form the bridge of the nose. They are thick and narrow above, but gradually become wider and thinner below. The superior border of each is serrated, and articulates with the frontal bone; the inferior unites with the nasal cartilage; the external edge articulates with the ascending process of the superior maxillary bone; and the internal with its fellow

Fig. 43.

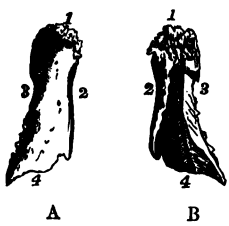


Fig. 43.—Right Nasal Bone. ⅔

A, from the front; B, from behind.

1, upper or frontal serrated border; 2, internal border for adjacent articulation; 3, external or superior maxillary border; 4, lower free border; in B, 4 is placed at the lower end of the groove for the nasal nerve.

and with the nasal spine of the frontal bone and the perpendicular plate of the ethmoid. The anterior surface, concave at its upper part, convex in the rest of its extent, presents a minute vascular foramen ; the posterior or nasal surface is marked by a groove for the passage of the nasal nerve.

THE LACHRYMAL BONE.

The lachrymal bone, or *os unguis*, is a thin scale of bone placed at the anterior and inner part of the orbit. It articulates superiorly with the frontal bone, posteriorly with the orbital plates of the ethmoid ; anteriorly it presents a longitudinal or vertical groove, and articulates with the ascending process of the superior maxillary bone, completing with it the groove for the lachrymal sac ; inferiorly it articulates in its greatest extent with the orbital plate of the superior maxillary bone, while its anterior

Fig. 44.

Fig. 44.—Right Lachrymal Bone, from the outside. ⅔

1, upper or frontal border ; 2, the orbital surface ; 3, lachrymal groove ; 4, the process which meets the inferior turbinated bone.

grooved part projects downwards, taking part in the formation of the lachrymal canal, and terminates in a pointed extremity, *hamulus lachrymalis*, which fits into an angle between the superior maxillary and inferior turbinated bone. The inner surface looks superiorly to the anterior ethmoidal cells, and inferiorly to the middle meatus of the nose.

THE INFERIOR TURBINATED BONE.

The inferior turbinated, or spongy bone, is a slender lamina, attached by one margin from before backwards along the lateral wall of the nose, and

Fig. 45.

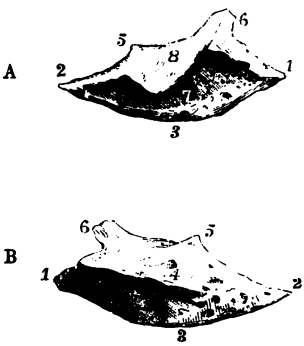


Fig. 45.—The Inferior Turbinated Bone of the Right Side. ⅔

A, from the outside ; B, from the inside.
1, anterior angle ; 2, posterior angle ; 1, 3, 2, inferior free border; 4, internal convex surface ; 5, part of the bone articulating with the uncinate process of the ethmoid ; 6, portion articulating with the lachrymal ; 7, the outer concave surface ; 8, the deflected scale of bone from the upper border, which, by union with the superior maxillary, forms a part of the inner wall of the maxillary sinus.

projecting into the nasal cavity, so as to divide the middle from the inferior meatus. It is slightly convoluted, its convexity looking upwards and inwards, and its free margin being dependent, slightly thickened, and rolled upon itself. The attached margin articulates anteriorly with the oblique ridge below the ascending process of the superior maxillary bone, and ascends abruptly to complete the lachrymal canal and articulate with the lachrymal bone ; behind this it bends downwards, forming part of the inner wall of the antrum below the entrance into that cavity ; above and behind this, it presents a small projection which articulates with the uncinate process of the ethmoid, and posteriorly it is attached to the horizontal line on the vertical plate of the palate bone.

This bone is marked by horizontal grooves and canals for vessels and nerves, but not, as the turbinations of the ethmoid are, with vertical grooves for the olfactory nerve.

THE INFERIOR MAXILLARY BONE.

The inferior maxilla, or lower jaw, is the thickest and strongest bone of the face, and moves on the rest of the skull by means of a pair of articular surfaces or condyles. It has the shape of an inverted arch bent forwards upon itself, and consists of a middle larger and horizontal part—the body, and of two rami or ascending branches.

Fig. 46.

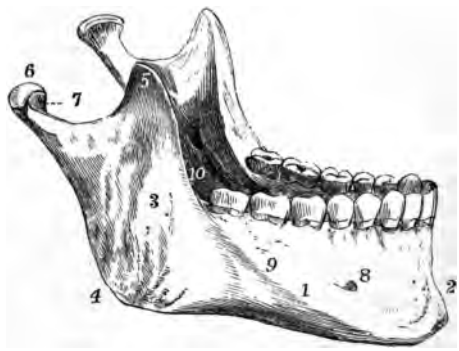


Fig. 46.—The Inferior Maxillary Bone, from the right side and above. ½

1, the body; 2, the symphysis; 3, the ramus; 4, the angle, near it the oblique ridges marked by the attachment of the masseter muscle; 5, the coronoid process; 6, the condyle or articular head; 7, placed in the sigmoid notch, points to the front of the neck; 8, the mental foramen; 9, the external oblique ridge; 10, the inferior dental foramen and mylohyoid groove of the left side. This figure represents a full set of the teeth of the lower jaw in middle life. (See also, for the view of the inner surface of the lower jaw, figure 53, the vertical section of the skull.)

The body is marked in the middle by a vertical ridge, indicating the original division of the bone into two lateral parts, and thence named the *symphysis*. The superior or *alveolar* border is hollowed out into sockets for the teeth. The inferior border, thicker anteriorly than beneath the ramus, is slightly everted in front, constituting the chin, or *mentum*, a prominence peculiar to the human skull. On the outer surface, on each side of the symphysis, below the incisor teeth, is a shallow depression, the *incisor fossa*, which gives origin to the levator menti muscle, and, more externally, the *labial* or *mental foramen*, which transmits the facial branches of the inferior dental nerve and artery. From beneath the mental foramen an elevation, the *external oblique line*, extends upwards and outwards to the anterior border of the ramus. The deep surface is marked, on each side of the symphysis, along the inferior margin, by a depression, indicating the anterior attachment of the digastric muscles, and above them by two pairs of prominent tubercles, *spinæ mentales*, placed closely together, giving attachment, the upper pair to the genio-hyo-glossi, and the lower to the genio-hyoidei muscles. An oblique prominent line, the *mylo-hyoidean ridge*, leading from beneath the spinæ mentales, upwards and outwards to the ramus, gives attachment to the mylo-hyoideus muscle. Above this line is a smooth depression for the sublingual gland, and beneath and external to it another for the submaxillary gland.

The *ramus* is thinner than the body of the bone, and its border forms, posteriorly and inferiorly with that of the body, an angle, called the angle of the jaw. The external surface is flat and marked by slight unevenness, and towards the angle by ridges at the place of attachment of the masseter

muscle. The internal surface presents at its middle the *inferior dental foramen*, leading into the *dental canal*, which lodges the dental nerve and vessels. Passing down from the sharp inferior margin of this foramen is the *mylo-hyoid groove* (occasionally a canal for a short space), marking the passage of the mylo-hyoid nerve with an accompanying artery and vein. Behind this, inside the angle, is a marked roughness for the internal pterygoid muscle.

Each ramus is surmounted by two processes, the condyle and the coronoid, which are separated by a deep excavation, the *sigmoid notch*. The *condyle* is continued upwards from the posterior part of the ramus. It is supported by a constricted portion, the *neck*, which presents anteriorly a depression, from which the external pterygoid muscle arises. The condyle is a transversely elongated convex articular process, whose major axis is directed obliquely, so that if prolonged it would meet with that of its fellow near the anterior margin of the foramen magnum. The *coronoid process* is continued vertically upwards in front, from the anterior margin of the ramus. It is pointed, and gives attachment by its margin and inner aspect to the temporal muscle. At its base, in front, is a groove, to which the buccinator muscle is attached.

The anterior margin of the ramus is placed at nearly a right angle to the alveolar border. The angle of the jaw, which is the meeting of the posterior border of the ramus with the base, is in the adult usually about 120°; in infancy it is as great as 140° or more; in strongly developed jaws it may be diminished to 110° or less; and in old and toothless jaws it is increased. These changes are connected with a variety of circumstances, among which may be noticed,—the development of the temporary and permanent teeth, the absorption of the alveolar arch in advanced age, the elongation of the face and upper jaw towards adult life, and the varying state of development of the masseter muscles at different periods.

THE HYOID BONE.

The hyoid bone, or *os linguæ*, is situated at the base of the tongue, and may be felt between the chin and the thyroid cartilage. It is suspended from the tips of the styloid processes of the temporal bones by a pair of slender bands, the *stylo-hyoid ligaments*, which are osseous in most animals. Hence, though not strictly a bone of the cranium or face, it properly falls to be considered in this place. It is shaped like the letter U, and consists of a body and two pairs of cornua.

Fig. 47.

Fig. 47.—THE HYOID BONE, FROM BEFORE. ⅔

1, the prominent part of the body; 2, the great cornu; 3, the lesser cornu.

The *body*, or central piece, is compressed from before backwards, and lies in a plane, directed downwards and forwards. Its anterior surface is convex, and marked in the middle by a vertical ridge, on each side of which are depressions for the attachment of muscles. Its posterior surface is concave, and is directed towards the epiglottis.

The *great cornua* project backwards from the sides of the body, and end in rounded extremities.

The *small cornua*, or *cornicula*, short and conical, project upwards and backwards from the place of junction of the body with the great cornua,

and give attachment at their extremities to the stylo-hyoid ligaments. They continue for a long time movable, as the cartilage which connects them remains unossified till an advanced period of life.

THE SKULL AS A WHOLE.

Fig. 48.

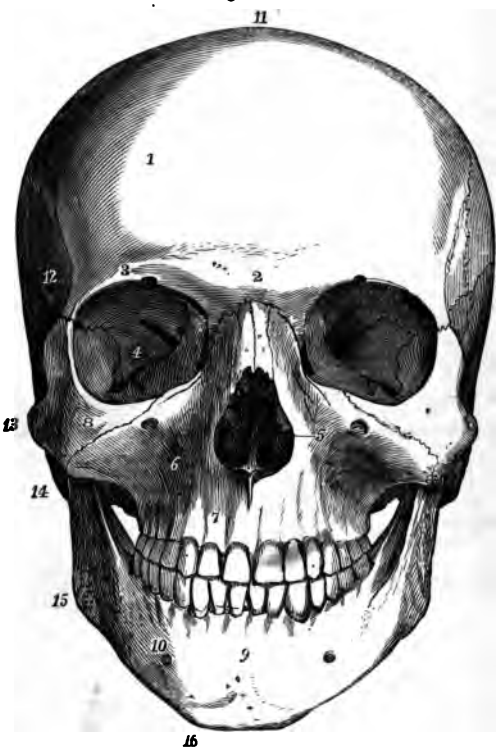


Fig. 48.—Front View of the Skull of a Young Man of about Twenty Years of Age. ½

Placed with the anterior nasal spine and the middle of the meatus auditorius externus in the horizontal plane. (In this, as in most other figures, the figures and letters of indication are placed only on one side.) 1, frontal eminence; 2, middle of the lower part of the frontal bone, or glabella, between the superciliary eminences, and above the transverse suture of union with the nasal and superior maxillary bones; 3, supra-orbital ridge at its middle—to the inside of the figure is the supra-orbital notch; 4, the orbit—the figure is placed on the orbital plate of the sphenoid bone, between the foramen lacerum orbitale and the spheno-maxillary fissure; 5, the anterior opening of the nares, within which are seen in shadow the nasal crest of the superior maxillary bones, the vertical plate of the ethmoid bone, and on each side the turbinated bones; 6, superior maxillary bone at the canine fossa—above the figure is the infra-orbital foramen; 7, myrtiform, or incisor foramen; 8, malar bone; 9, symphysis menti and median ridge; 10, body of the lower jaw, above the outer oblique ridge and the mental foramen; 11, vertex, immediately over the coronal suture; 12, temporal fossa, at the meeting of the frontal, parietal, temporal, and sphenoid bones; 13, zygoma; 14, mastoid process; 15, angle of the jaw; 16, mental angle. In this skull there are fourteen teeth in each jaw, the wisdom teeth having not yet appeared.

THE SUTURES.

The sutures of the skull are best distinguished when named from the bones between which they lie, as, for example, occipito-parietal, occipito-mastoid, fronto-ethmoid, parieto-sphenoid, &c. Those which occur in the arch of the skull require more particular notice. The cranium is intersected superiorly by three great serrated sutures, two of which, placed transversely, correspond to the anterior and posterior margins of the parietal bones, while the third lies in the middle line and passes between them. On each side also there runs an irregular longitudinal line of suture from the malar to the

occipital bone, bounded by the frontal and parietal bones above, and the malar, sphenoid, and temporal bones below.

Fig. 49.

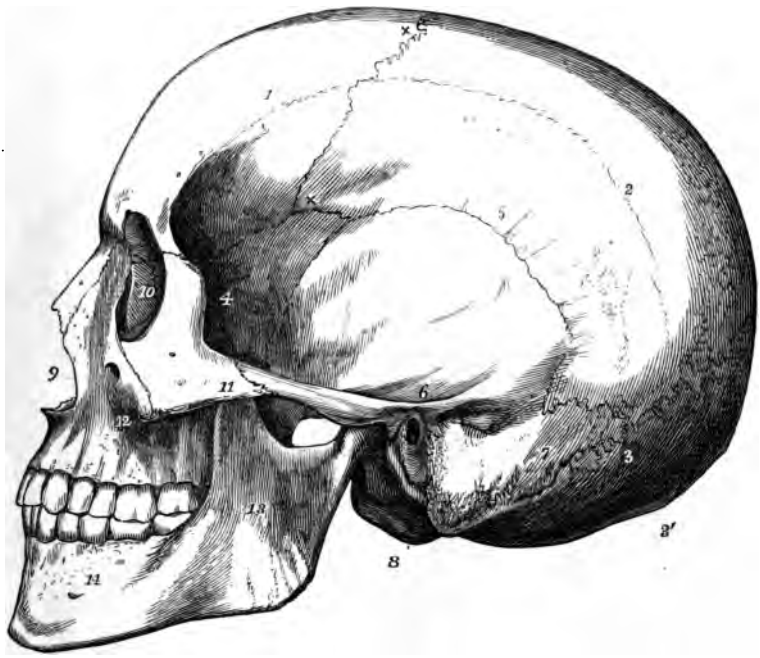


Fig. 49.—Lateral or Profile View of the same Skull as that represented in the preceding Figure. ½

Placed so that a horizontal line passes through the anterior nasal spine and meatus anditorius externus. 1, frontal bone; 2, parietal bone—figures 1 and 2 are placed above the temporal ridge of these bones; × ×, coronal suture; 3, occipital bone—the figure is placed at the lower end of the lambdoidal suture, and at its meeting with the additamentum suturæ squamosæ and additamentum suturæ lambdoidalis; 3', external or posterior occipital protuberance; 4, great wing of the sphenoid bone, between the frontal, anterior inferior angle of the parietal and squamous part of the temporal bones; 5, the summit of the squamous part of the temporal bone; 6, at the lower part of the same and at the root of the zygoma immediately over the meatus auditorius externus; 7, mastoid portion of the temporal bone, in front of which is the mastoid process—the figure is close to the mastoid foramen; 8, the left condyloid process of the occipital bone; 9, the anterior opening of the nares or nasal notch; 10, the inner wall of the orbit, on the lachrymal bone; 11, the malar bone, close to its junction with the zygoma; 12, superior maxillary bone—the figure is placed on the body behind the canine fossa; 13, ramus of the lower jaw, at its middle; 14, body of the lower jaw, near the mental foramen.

The *fronto-parietal*, or *coronal suture*, connects the frontal and the two parietal bones. It commences at each side, about an inch behind the external orbital process of the frontal bone, above the great wing of the sphenoid, and mounts upwards and backwards to the vertex. It presents the most marked dentations in the middle of each lateral half; at the summit the serrated surface is oblique, the frontal bone overlapping the parietal, while similarly at the lower part the parietal overlaps the frontal.

The *occipito-parietal*, or *lambdoidal suture*, situated between the occipital

and parietal bones, inclines downwards and outwards on each side and has somewhat of the form of the Greek letter Λ. The *occipito-mastoid suture* (*additamentum suturæ lambdoidalis*) is in continuation with it.

The *parietal*, or *sagittal suture*, connects the two parietal bones: it is continued in children, and not unfrequently in adults, by a suture between the two halves of the frontal bone, the *frontal suture*.

The *spheno-parietal suture*, the line of contact of the parietal bone and great wing of the sphenoid, is about half an inch in extent. It is absent only in very rare cases, and then the frontal and temporal bones come into contact.

The *temporo-parietal suture* consists of two very distinct parts, the *squamous suture*, arched in direction, in which the scale-like margin of the squamous portion of the temporal bone overlays the similar margin of the parietal, and the *parieto-mastoid suture* (*additamentum suturæ squamosæ*), which is thick and serrated.

From the nature of the squamous suture, the inferior margins of the parietal bones cannot be pressed outwards by forces acting either from above or from within, without at the same time pushing before them the squamous margins of the temporals. When the pars squamosa is thus acted on, it may either bulge outwards alone, or may press downwards the base of the pars petrosa. Both phenomena are observable in broad skulls.

Ossa Triquetra.—Supernumerary ossicles are found in a great number of skulls, interposed between the cranial bones, like islets in the sutures. They are called *ossa triquetra, ossa Wormii, ossa suturarum*, &c. They are of irregular form, with margins adapted to the character of the sutures in which they are situated. They are most frequently found in the occipito-parietal suture, where they occur sometimes in great numbers, more or less symmetrically arranged; in other instances, one or several bones of considerable size may occupy the place of the superior part of the occipital. They are less frequent in the parietal suture and at the anterior fontanelle, are found only in small numbers in the fronto-parietal suture, and rarely occur in the squamous. A single triquetrous bone intervenes sometimes between the parietal and sphenoid; and still more frequently between the parietal and the place of meeting of the squamous and mastoid portions of the temporal.

GENERAL CONFORMATION OF THE SKULL.

THE EXTERIOR.

The surface of the skull may be conveniently divided into superior, inferior, anterior, and lateral regions.

The superior region, extending from the supra-orbital ridges in front to the superior curved line of the occipital bone behind, and bounded laterally by the temporal ridges, is smooth and convex, covered only by the muscular fibres and fascia of the occipito-frontalis muscle and the integument. It is of an oval form, broader in the parietal than the frontal region, flattened in front, and projecting somewhat in the middle behind.

The anterior region of the skull, below the forehead, presents the openings into the orbits, bounded by the frontal, malar, and superior maxillary bones; and between the orbits, the bridge of the nose, formed by the nasal bones and ascending processes of the superior maxillaries. Below the nasal bones is the nasal aperture, of an inverted heart shape: its thin margin gives attachment to the nasal cartilages, and projects forwards in the middle line below as the nasal spine. Below the nasal aperture are the incisor fossæ of the upper jaw; below the orbits are the canine fossæ; and external to the canine fossæ are the prominences of the cheeks, formed by the anterior inferior parts of the malar bones. The lower jaw completes the

skeleton of the face below. The foramina in this region, on each side, are the supra-orbital foramen or notch in the superior margin of the orbit, the infra-orbital foramen below the inferior margin of the orbit, the mental foramen of the lower jaw, and the small irregular foramina of the malar bone.

The *orbits* are pyramidal fossæ, irregularly quadrilateral, with their bases

Fig. 50.

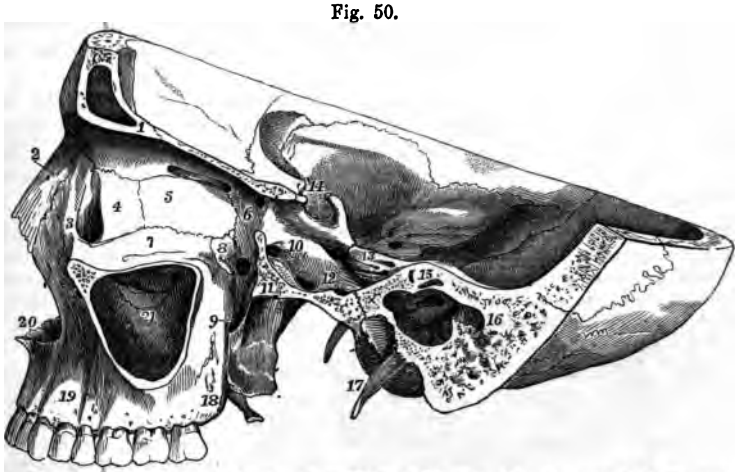


Fig. 50.—Section of the Skull of a Man of Middle Age, in two planes, one of which passes vertically through the Left Orbit to the inner side of its middle, and the other obliquely from behind the Orbit, backwards and outwards, through the Tympanum and Mastoid Process, and to the outside of the Foramen Rotundum and Foramen Ovale. ½

1, section of the frontal bone in the roof of the orbit; 2, left nasal bone; 3, nasal process of the superior maxillary bone; 4, left lachrymal bone, and in front the groove of the nasal duct; 5, placed on the os planum of the ethmoid bone, below the anterior of the ethmoid foramina; 6, is placed below the root of the lesser wing of the sphenoid bone, between the optic foramen and the posterior internal orbital or ethmoid foramen, and close to the foramen lacerum orbitale; 7, floor of the orbit, formed by orbital plate of the superior maxillary bone—the figure is placed close to the inside of the infra-orbital groove; 8, is placed on the orbital plate of the palate bone, in front of and above the spheno-palatine foramen and spheno-maxillary fossa; 9, marks the upper extremity of the posterior palatine (or palato-maxillary) canal; towards 11 in the fossa is the opening backwards of the Vidian canal; 10, the cranial opening of the foramen rotundum—its anterior opening is seen in the spheno-maxillary fossa; 11, section of the great wing of the sphenoid bone outside the round and oval foramina; 12, is placed close to and between the spinous and oval foramina; 13, is placed on the anterior surface of the petrous bone, near the apex, or in the fossa of the Gasserian ganglion; towards the orbit are seen the foramen lacerum anterius, sigmoid groove of the internal carotid artery, and pituitary fossa, below the figure and externally the hiatus Fallopii; 14, the pituitary fossa, with the anterior and posterior clinoid processes; 15, section of the petrous bone above the labyrinth; two of the semicircular canals are opened; immediately below is the tympanum. The inner wall is seen with the promontory, fenestra ovalis and pyramid in shadow; forwards, at ×, the opening of the tympanum towards the Eustachian canal, and backwards, below 16, the opening into the mastoid cells; 17, left styloid process—that of the right side is seen in perspective below the skull, close by the occipital condyle; 18, tuberosity of the superior maxilla; 19, canine fossa; 20, nasal notch and anterior nasal spine; 21, inner wall of the antrum seen by the removal of its outer wall; above the figure is an irregular opening, *viz.*, the opening of the antrum into the middle meatus of the nose, and above that the uncinate process of the ethmoid bone. The figure 21 is placed below the deflected plate of the inferior turbinated bone, where it completes a part of the inner wall of the antrum.

directed forwards and outwards, their inner walls being nearly parallel, and their outer walls diverging so much as to be at right angles one to the other. The roof of each orbit is formed by the orbital process of the frontal and the small wing of the sphenoid bone; the floor consists of the orbital processes of the malar and superior maxillary bones, and of the small orbital surface of the palate bone at the back part; the inner wall consists of the ascending process of the superior maxillary, the lachrymal, the ethmoid, and the sphenoid bone; and the outer wall of the orbital surfaces of the malar bone and great wing of the sphenoid. The *sphenoidal fissure* (foramen lacerum orbitale), at its inner extremity, occupies the apex of the orbit, while its outer and narrower part lies between the roof and the external wall. The foramen opticum is internal and superior to the sphenoidal fissure. In the angle between the external wall and the floor is the *spheno-maxillary fissure*, bounded by the sphenoid, palate, superior maxillary, and malar bones, and leading into the spheno-maxillary fossa at its back part, and the zygomatic fossa at its fore part. Passing forwards from the margin of the spheno-maxillary fissure is the commencement of the infra-orbital canal, grooving the posterior part of the floor of the orbit. At the fore part of the inner wall is the lachrymal groove, formed by the superior maxillary and lachrymal bones, and leading into the nasal duct: further back, between the ethmoid and frontal bones are the anterior and posterior internal orbital foramina; in the anterior margin of the roof is the supra-orbital foramen or notch; and in the outer wall are the minute foramina which perforate the malar bone.

The LATERAL REGION of the skull presents in a horizontal line from behind forwards the mastoid process, the external auditory meatus, the glenoid fossa, with the condyle of the lower jaw, and the *zygomatic* or *malar arch*, formed by the zygomatic process of the temporal bone and the posterior part of the malar. When the head of the lower jaw is in the glenoid cavity, the coronoid process lies internal to the malar arch. The upper part of the space bridged over by this arch is called the *temporal fossa*, the lower part the *zygomatic fossa*, the line of division being the rough ridge which divides the external surface of the great wing of the sphenoid bone into an upper and lower portion. The temporal fossa is occupied by the temporal muscle; it is bounded superiorly by the temporal ridge; and the frontal, parietal, sphenoid and malar bones take part in its formation. The zygomatic fossa is occupied in part by the external pterygoid muscle; its wall is formed internally by the external pterygoid plate, superiorly by the lower part of the great wing of the sphenoid bone, and anteriorly by the superior maxillary. Inferiorly the external pterygoid plate comes nearly into contact with the superior maxillary bone, but is usually separated from it, though not always, by a thin portion of the pyramidal process of the palate bone; superiorly, it is divided from it by the *pterygo-maxillary fissure*, a vertical opening, which leads into the spheno-maxillary fossa, and which is continued above into the outer extremity of the horizontal spheno-maxillary fissure opening into the orbit.

The *spheno-maxillary fossa* is the space which lies in the angle between the pterygo-maxillary fissure and the inner or posterior half of the spheno-maxillary fissure. It is bounded posteriorly by the external pterygoid process and inferior division of the anterior surface of the great wing of the sphenoid bone, anteriorly by the tuberosity of the superior maxillary bone, and internally by the vertical plate of the palate bone. Into this narrow space five foramina open, *viz.*, on the posterior wall, the foramen rotundum, the Vidian canal, and, between the sphenoidal process of the

palate bone and the root of the internal pterygoid plate, the pterygo-palatine canal; on the inner wall, the spheno-palatine foramen formed by the palate bone and a small part of the sphenoidal spongy bone, and opening into the nasal cavity; and inferiorly, the posterior palatine canal, which leads down to the palate between the palatal and superior maxillary bones.

Fig. 51.

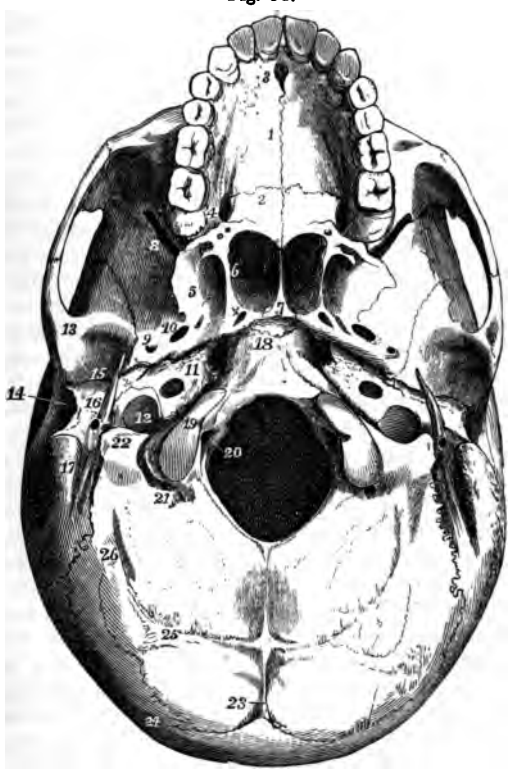


Fig. 51.—Basis of the Skull, viewed from below, without the Inferior Maxillary Bone. ½

1, palatine plate of the superior maxillary bone—the figure is placed near the mesial suture; 2, palatine plate of the palate bone—the figure is placed below the transverse suture between the palate and superior maxillary bones; 3, the anterior palatine foramen, showing four smaller foramina within; 4, is placed outside the posterior palatine foramen, inside the tuberosity of the superior maxilla, and in front of the smaller posterior palatine foramina in the pyramidal process of the palate bone; 5, inner surface of the external pterygoid plate of the sphenoid bone; 6, is placed within the posterior opening of the nares on the inner surface of the internal pterygoid plate; 7, is upon the upper part of the posterior edge of the vomer; × marks the posterior opening of the pterygo-palatine canal, and is placed above or in front of the posterior opening of the Vidian canal in the foramen lacerum anterius; 8, spheno-maxillary fissure leading into the orbit; 9, foramen spinosum; 10, foramen ovale; 11, is placed on the apex of the petrous bone, between the foramen lacerum anterius and the inferior opening of the carotid canal; 12, is placed in the jugular (or digital) fossa of the temporal bone, and indicates the foramen lacerum posterius; 13, on the articular eminence of the inner root of the zygoma in front of the glenoid cavity of the temporal bone; 14, meatus auditorius externus; 15, glenoid cavity in front of the fissure of Glaser; 16, tympanic plate or posterior part of the glenoid cavity, close to the styloid process, below which is seen the stylo-mastoid foramen; 17, mastoid process, and to its inside the digastric and occipital grooves; 18, basilar process of the occipital bone, and in front the mark of the still incomplete union with the body of the sphenoid bone; 19, condyloid articular process of the occipital bone; 20, is placed in the foramen magnum, and points to the lower opening of the anterior condyloid foramen; 21, posterior opening of the posterior condyloid foramen; 22, jugular process of the occipital bone, to its inner side the jugular notch, to its outer and above, the stylo-mastoid foramen; 23, is placed on one side, in front (above in the figure) of the external occipital protuberance, and the line indicates the upper part of the external occipital spine; 24, superior curved line of the occipital bone; 25, inferior curved line; 26, groove and ridge of insertion of obliquus capitis superior muscle.

The INFERIOR REGION, or *external base of the skull*, extending from the incisor teeth to the occipital protuberance, and transversely from the mastoid process and dental arch on one side to the corresponding points on the other, is divisible, on removal of the lower jaw, into an anterior, middle, and posterior part.

The *anterior part* consists of the palate and the alveolar arch. It is traversed longitudinally by a mesial suture, and transversely by that between the maxillary and palate bones. Anteriorly, in the middle line, is the anterior palatine foramen, with the four smaller foramina contained within it; posteriorly, on each side, at the base of the alveolar border, is the posterior palatine foramen, and external and posterior to that, the posterior and external small palatine foramina. The palate is surrounded in front and on the sides by the alveolar arch and teeth of the upper jaw.

The *middle part*, extending back to the front of the foramen magnum, is the most complicated. Its central portion has been called the *guttural fossa*. In the middle line is the basilar process of the occipital bone, and in front of that the body of the sphenoid bone, concealed anteriorly by the extremity of the vomer. On each side, the petrous portion of the temporal bone reaches as far forwards as the extremity of the basilar process; and between the petrous and squamous portions of the temporal is the back part of the great wing of the sphenoid bone. Between this division of the base of the skull and the palate are the *posterior nares*, separated by the vomer, and bounded above by the body of the sphenoid bone, below by the horizontal plates of the palate bones, and on the sides by the internal pterygoid processes. Between the pterygoid plates is the pterygoid fossa; and placed in an oblique line backwards and outwards from this are the foramen ovale, foramen spinosum, and processus spinosus; while behind and parallel to these is a *groove for the Eustachian tube*, formed by the margins of the sphenoid bone and pars petrosa, leading into the Eustachian orifice, and in a line with the fissure of Glaser. Between the apex of the pars petrosa, the basilar process, and the sphenoid bone, is the *foramen lacerum anterius basis cranii*, called also *foramen lacerum medium*, on the external wall of which opens the carotid canal, and on the anterior the Vidian canal; it is closed inferiorly by a plate of cartilage, but its area is crossed by the internal carotid artery and by the Vidian nerve. Behind the pars petrosa, and bounded posteriorly by the jugular fossa of the occipital bone, is the *foramen jugulare*, or *foramen lacerum posterius:* it is divided into a large external and posterior part, bounded anteriorly by the jugular fossa of the temporal bone, and occupied by the jugular vein; and a small anterior and inner part, bounded by a portion of the pars petrosa distinct from the jugular fossa, and transmitting the glosso-pharyngeal, vagus, and spinal accessory nerves. The two parts of the foramen lacerum posterius are sometimes completely separated by a spiculum of bone. Anterior to this opening is the carotid foramen, external to it is the stylo-mastoid foramen and styloid process, and internal to it is the anterior condyloid foramen.

The *posterior part* of the inferior region presents on each side of the fore part of the foramen magnum, in a transverse line outwards, the occipital condyle, the rough surface for the rectus capitis lateralis muscle, the occipital groove of the temporal bone, the digastric fossa, and the mastoid process. Behind is the inferior division of the expanded part of the occipital bone, with its ridges and muscular impressions.

THE INTERIOR OF THE SKULL.

1. THE CRANIAL CAVITY.—The walls of the cranium present two layers of compact tissue, the *outer* and *inner tables*, and between these, in the greater part of their extent, cancellated substance, called *diploe*. The inner

Fig. 52.

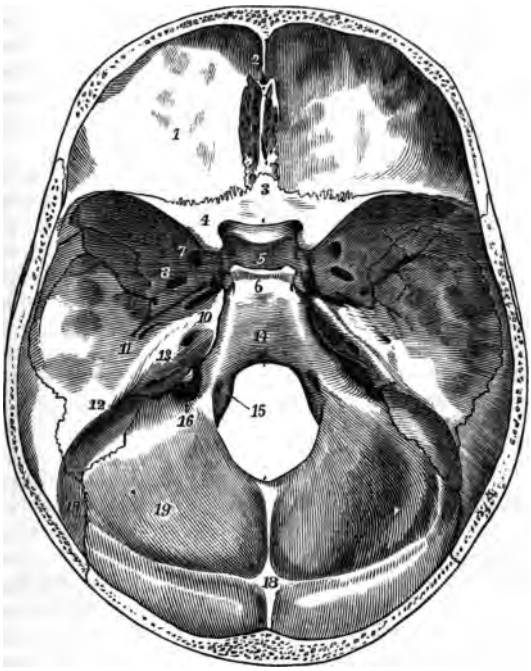


Fig. 52. — INTERNAL BASIS OF THE SKULL, OPENED BY A HORIZONTAL INCISION ONE INCH ABOVE THE SUPRA-ORBITAL ARCHES AND EXTERNAL OCCIPITAL PROTUBERANCE. ½

1, anterior fossa and roof of the orbit, as formed by the frontal bone, marked by impressions of cerebral convolutions; 2, is close to the foramen cœcum and in front of the crista galli and cribriform plate of ethmoid; 3, is close behind the ethmoidal spine of the sphenoid and behind the cribriform plate; 4, lesser wing of Ingrassias, terminating posteriorly in the anterior clinoid process, inside which the inner opening of the optic foramen is seen; 5, the pituitary fossa, in front of it the olivary eminence and transverse groove of the optic commissure; 6, the inclined plate of the body of the sphenoid, or dorsum sellæ, terminating in the posterior clinoid processes, and to the side of these the sigmoid groove of the internal carotid artery; 7, foramen rotundum, to the inner side of which anteriorly, but not seen, is the foramen lacerum orbitale; 8, foramen ovale; 9, foramen spinosum; 10, is placed on the ridge of the petrous bone, near its apex, and to the inside of the hollow occupied by the Gasserian ganglion; in front of this is the foramen lacerum anterius; 11, is placed internal to the eminence of the superior semicircular canal of the labyrinth, and behind the hiatus Fallopii; 12, is upon the prominent ridge of the petrous bone, in which (on the opposite side) the superior petrosal groove is marked; 13, is upon the posterior surface of the petrous bone—to the inside, the meatus auditorius internus, behind, the scale of bone covering the aqueduct of the vestibule; 14, basilar groove; 15, inner or upper opening of the anterior condyloid foramen; 16, jugular part of the foramen lacerum posterius; 17, outer part of the groove of the lateral sinus, where it crosses the lower angle of the parietal bone; 18, internal occipital protuberance, and between it and the foramen magnum, the internal occipital spine; between 17 and 18, the upper part of the groove of the lateral sinus, between 17 and 16 the lower part; 19, cerebellar fossa.

or *vitreous* table has a smooth, close-grained, shining appearance, is hard and brittle, and is thrown into irregular digitate impressions corresponding to the convolutions of the brain. The thinnest portions of the cranial wall are the cribriform plate of the ethmoid and the orbital plates of the frontal bone, in both of which the diploe is entirely absent; in the middle part of the inferior occipital fossæ, and in the squama and glenoid fossa of the temporal, the bone is also very thin and compact.

The upper part of the cranial cavity forms an unbroken arch; the lower part is divisible into three parts or fossæ having different levels.

The *anterior fossa*, formed by the orbital plates of the frontal bone, the small wing of the sphenoid, and the cribriform plate of the ethmoid, supports the anterior lobes of the brain. It is deepest opposite the ethmoid bone, and convex over the orbits. It is pierced by the foramina of the cribriform plate, and by the foramen cœcum in front of the crista galli of the ethmoid bone.

The *middle fossa* presents a mesial and two lateral parts. The mesial part is small, being formed by the olivary process and sella turcica of the sphenoid bone, and limited behind by the dorsum sellæ. The lateral part on each side, formed by the great wing of the sphenoid, the squamous part of the temporal, and the anterior surface of the petrous part, lodges the middle lobe of the brain. The foramina of the middle fossa are the foramen opticum, the sphenoidal fissure, foramen rotundum, foramen ovale, foramen spinosum, foramen lacerum medium, and hiatus Fallopii.

The *posterior fossa*, deeper and larger than the others, extends back to the occipital protuberance, and lodges the cerebellum and medulla oblongata. The occipital bone and the petrous and mastoid portions of the temporal bone take part in its formation. In the posterior surface of the pars petrosa, which limits this fossa anteriorly on each side, is the internal auditory meatus, below it is the foramen lacerum posterius, below and internal to that is the anterior condyloid foramen, and in the middle line is the foramen magnum.

Grooves for Bloodvessels.—The groove of the middle meningeal artery commences at the foramen spinosum of the sphenoid bone, and ramifies principally on the squamous portion of the temporal bone and on the parietal. The groove of the internal carotid artery lies on the side of the body of the sphenoid bone, and terminates on the internal margin of the anterior clinoid process. The groove of the superior longitudinal sinus, commencing at the foramen cœcum in front of the crista galli of the ethmoid bone, enlarges as it passes backwards in the middle line of the roof of the skull, and terminates at the internal occipital protuberance. At that point commence the grooves of the lateral sinuses, which pass outwards on the occipital bone, cross the posterior inferior angles of the parietal bones, descend on the mastoid portions of the temporal bones, run inwards again on the occipital, and turn forwards to terminate at the jugular foramen. The groove of the inferior petrosal sinus lies between the petrous portion of the temporal bone and the basilar process; that of the superior petrosal sinus extends along the superior angular edge of the petrous portion.

The Nasal Cavities and Communicating Sinuses.—The nasal cavities are placed one at each side of the middle line, being separated by a vertical septum. They open in front and behind by the anterior and posterior nares already described, and communicate by foramina with the sinuses of the frontal, ethmoid, sphenoid, and superior maxillary bones. Their vertical extent, as well as that from before backwards, is considerable, but the transverse width of each is very limited, especially in the upper part.

The *internal wall*, or *septum narium*, is formed principally by the central plate of the ethmoid bone and the vomer; but the frontal spine, the rostrum of the sphenoid bone, and the crests of the maxillary and palate bones likewise enter into its composition. It presents a great angular deficiency in front, which in the recent state is filled up by the septal cartilage. In

very many cases it deviates from the middle line, and more frequently to the left than to the right side. The concave side is that on which the ala of the vomer is most intimately connected with the ethmoid.

Fig. 53.

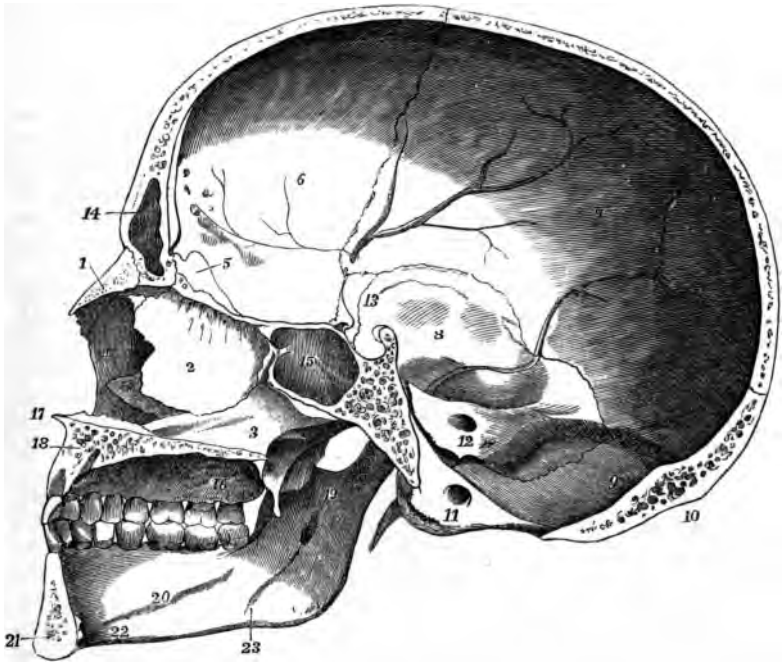


Fig. 53.—VERTICAL SECTION OF THE ADULT SKULL IN AN ANTERO-POSTERIOR PLANE, PASSING A LITTLE TO THE LEFT OF THE MIDDLE, SHOWING THE SEPTUM NARIUM, &c. ½

1, nasal bone; 2, perpendicular plate of the ethmoid bone, with olfactory foramina and grooves at its upper part; 3, vomer; 4, nasal process of the right superior maxillary bone, forming part of the wall of the right nasal fossa; below this the anterior extremity of the right inferior turbinated bone, and below that, at ×, the fore part of the right inferior meatus of the nose; 5, crista galli; 6, inner surface of the frontal bone; 7, of the parietal bone; 8, squamous part of the temporal,—all these being marked by grooves of cerebral convolutions and meningeal vessels; 9, placed on the occipital bone below the internal or anterior occipital protuberance; 10, the posterior or external occipital protuberance; 11, placed on the condyloid process below the anterior condyloid foramen; 12, placed on the posterior surface of the petrous bone below the meatus auditorius internus; between 9 and 12 the groove of the right lateral sinus, crossing also the mastoid bone; 13, placed above the sella turcica and between the anterior and posterior clinoid processes; 14, part of the left frontal sinus, the figure being placed on the left side of the septum, between the left and the right sinus; 15, part of the left sphenoidal sinus, the figure being placed on the septum of the sinuses; 16, hard palate and alveolar arch—the figure is placed near the lower opening of the posterior palatine canal, and the grooves which extend forwards from it; 17, anterior nasal spine; 18, section of the left superior maxillary bone, and near the place to which the line points, the section of the lower part of the anterior palatine canal; 19, placed on the inner surface of the ramus of the lower jaw, below the sigmoid notch, and above the inferior maxillary foramen; 20, inner surface of the body of the jaw on the oblique or mylo-hyoid ridge; 21, section of the lower jaw, near the symphysis; behind the symphysis, and between 21 and 22, the mental or genioid spines; 23, groove for the mylo-hyoid nerve.

The *roof* is horizontal in its middle part, but sloped downwards before and behind. The middle part is formed by the cribriform plate of the ethmoid bone, the fore part by the frontal and nasal bones, and the back part by the sphenoidal spongy bone.

The *floor*, formed of the palate plates of the maxillary and palate bones, is smooth, and concave from side to side. Towards its anterior extremity is the superior orifice of the incisor canal.

Fig. 54.

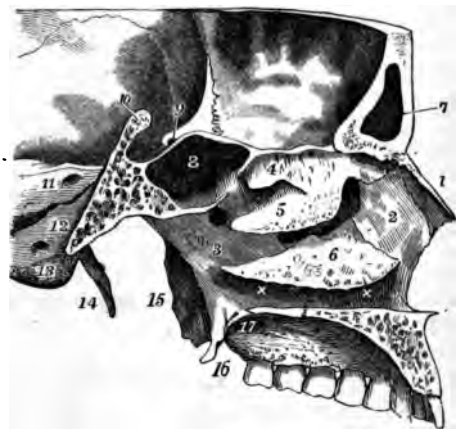


Fig. 54.—Vertical Antero-Posterior Section of a Part of the Cranium, to the Left of the Middle, viewed from the Inner Side, to show the Outer Wall of the Left Nasal Fossa, &c. ½

1, nasal bone; 2, nasal process of the superior maxillary bone; 3, ascending plate of the palate bone; 4, superior turbinated bone of the ethmoid—below it the superior meatus, behind it the opening into the left sphenoidal sinus; 5, the middle turbinated bone—below it the middle meatus, in which are seen the uncinate process of the ethmoid, and between it and the inferior turbinated bone the opening into the maxillary sinus, superiorly and anteriorly, the opening of the infundibulum and ante.ior ethmoidal cells; behind it, and above 3, the spheno-palatine foramen; 6, the inferior turbinated bone—below it the inferior meatus × ×, below these marks the section of the palatine plates of the left palate and superior maxillary bones; 7, the left frontal sinus; 8, the left sphenoidal sinus; 9, the left optic foramen in the root of the lesser wing of the sphenoid and anterior clinoid process; 10, the ridge of the dorsum sellæ divided; and between 9 and 10, the sella turcica; 11, is placed on the posterior surface of the petrous bone, close to the internal auditory meatus; 12, is placed on the basilar process of the occipital bone, close to the foramen lacerum posterius; 13, is placed below the anterior condyloid foramen; 14, left styloid process; 15, external, and 16, internal pterygoid processes; 17, posterior palatine canal and grooves.

The *external wall* is the most extensive. The bones which take part in its formation are the nasal, superior maxillary, ethmoid, lachrymal, inferior spongy, and palate bones, and the internal pterygoid plates. The superior and inferior turbinated processes of the ethmoid bone (superior and middle turbinated bones), and the inferior spongy bone, projecting inwards, overhang three galleries or *meatus*. The *superior meatus*, very short, is directed downwards and forwards between the superior and inferior turbinated processes of the ethmoid bone; into it open anteriorly the posterior ethmoidal cells, and posteriorly the spheno-palatine foramen. The *middle meatus*, the space between the inferior turbinated process of the ethmoid and the inferior spongy bone, communicates at its fore part with the anterior ethmoidal cells, and, by means of the infundibulum, with the frontal sinus, while in its middle is the opening of the maxillary sinus. The *inferior meatus*, longer than the others, lies below the inferior spongy bone, between it and the floor of the nasal cavity; in its fore part is the orifice of the nasal duct.

The SINUSES are hollows within certain cranial bones, which communicate with the nasal cavities by narrow orifices, and are named *ethmoidal*, *frontal*, *sphenoidal*, and *maxillary*. The maxillary sinus begins to be formed about the fourth month of fœtal life ; the frontal, ethmoidal, and sphenoidal first appear during childhood, but remain of small size up to the time of puberty, when they undergo a great enlargement. In advanced life they all increase in size by absorption of the cancellated tissue in their vicinity. The *ethmoidal sinuses* are numerous smaller spaces in the lateral masses of the ethmoid bone. The *frontal sinuses*, formed in the substance of the frontal bone, communicate with the middle meatus narium through the infundibula of the ethmoid bone. The *sphenoidal sinuses*, hollowed out in the sphenoid bone, and limited below and in front by the sphenoidal spongy bones, open anteriorly opposite the posterior ethmoidal cells.

The *maxillary sinus* is of an irregular pyramidal form ; its apex points to the malar tuberosity ; its sides are formed by the orbital and lateral plates of the superior maxillary bone ; its base, or internal wall, which separates it from the nasal cavity, is formed by the maxillary, palate, and inferior turbinated bones, and the uncinate process of the ethmoid ; an irregular gap or deficiency being left between the uncinate process and the inferior turbinated bone, by which the sinus opens into the middle meatus. The alveolus of one of the molar teeth generally forms a marked projection in the floor of the sinus, at its outer part.

DEVELOPMENT OF THE SKULL.

EARLY DEVELOPMENT OF THE HEAD.—When the head of the embryo has become so far developed as to rise completely out from the plane of the germinal membrane, two curvatures forwards are observed, the posterior of which is at the junction of the head with the spinal column, while the anterior is opposite the second cerebral vesicle, and is so placed that the fore part of the skull is bent at right angles to the back part. Behind the anterior curvature, the ventral margins of the dorsal plates are thrown on each side into four processes, the *branchial* or *visceral arches*, behind each of which is a fissure or *branchial cleft* in which the epithelial layer of

Fig. 55.

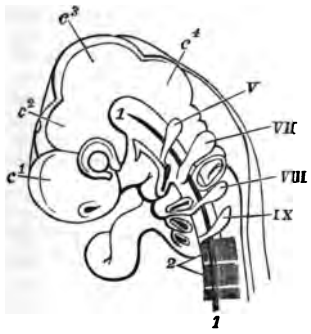
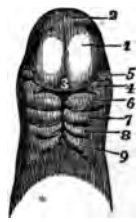


Fig. 55.—MAGNIFIED SIDE VIEW OF THE HEAD AND UPPER PART OF THE BODY OF AN EMBRYO-CHICK OF THE FOURTH DAY (adapted from Remak and Huxley).

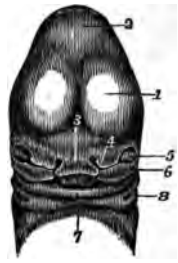
1, chorda dorsalis; 2, three of the upper primitive cervical vertebræ; C^1, first cerebral vesicle, with the nasal fossa below ; C^2, second part of the first cerebral vesicle, or thalamus opticus, with the eye below it ; C^3, the middle cerebral vesicle ; C^4, the cerebellum, between which and the cervical vertebræ is the medulla oblongata, these two constituting the first and second parts of the third cerebral vesicle. At the upper part of the chorda dorsalis, where it afterwards reaches the post-sphenoid, is seen the rectangular bend of the middle of the cranium, which takes place at the sella turcica ; and in front of this, towards the eye, the pointed infundibulum ; V, the rudiment of the trigeminus nerve ; VII, the facial ; VIII, the vagus ; IX, the hypoglossal ; in front and below these numbers respectively, first the upper and lower jaw, or first branchial arch, with the first cleft, which becomes the meatus auditorius externus ; and lower down the second, third, and fourth branchial arches and clefts in succession ; in front of these the aortic bulb attaches the heart ; between VII and VIII, the auditory vesicle.

the gullet passes out and becomes continuous with that of the integument. In a human embryo of three weeks of age all the arches are visible (Thomson). The first or highest visceral arch is the first to appear, and it is likewise the first to unite with its fellow of the opposite side: it forms by its lower part the outline of the lower jaw. The posterior or upper part of the first branchial cleft remains as the external aperture of the ear, the tympanic cavity and the Eustachian tube, while its anterior part together with the whole of the other branchial clefts are filled up. Connected with the upper edge of the first visceral arch, at its origin, a process is developed, the *maxillary lobe*, which passes forwards beneath the eye, forming the side part of the face. The eyes are formed in connection with the sides of the anterior cerebral vesicle, and, in front of them, a quadrilateral mesial lobe, the *middle frontal process*, passes down and forms the nose and middle part of the upper lip. At the angles of the extremity of the middle frontal process are two slight lobes, the *internal nasal processes* of Kölliker; above these are two notches, the rudimentary nostrils, and between the nostrils and eyes another pair of lobes, the *external nasal processes* of Kölliker, or *lateral frontal processes* of Reichert. The maxillary lobe becomes united to the internal and external nasal processes; but between it and the latter there is left the nasal duct. About the ninth week the inferior parts of the maxillary lobes, having sent projections inwards, are united in the middle line and form the palate.

Fig. 56.



A



B

Fig. 56.—A. Magnified view from before of the Head and Neck of a Human Embryo of about three weeks (from Ecker, Icones Physiol. Tab. xxix. fig. I.).

1, anterior cerebral vesicle or cerebrum; 2, middle ditto; 3, middle or naso-frontal process; 4, superior maxillary process; 5, eye; 6, inferior maxillary process or first visceral arch, and below it the first cleft; 7, 8, 9, second, third, and fourth arches and clefts.

B. Anterior view of the Head of a Human Fœtus of about the fifth week (from Ecker, as before, fig. IV.).

1, 2, 3, 5, the same parts as in A; 4, the external nasal or lateral frontal process; 6, the superior maxillary process; 7, the lower jaw; ×, the tongue; 8, first branchial cleft becoming the meatus auditorius externus.

Formation of the cranium.—The chorda dorsalis passes into the base of the skull, as far forwards as the sphenoidal region. According to the observations of H. Müller on the calf (Ueber das Vorkommen von Chordaresten, &c., in Zeitschr. für Rat. Med. 3rd series, vol. ii.), it extends from the odontoid process of the axis through the basilar process of the occipital bone to the back of the dorsum sellæ, which it pierces, and is lost behind the pituitary body. Before attaining the osseous state, the cranium passes through a membranous and cartilaginous condition, in which it is termed the *primordial cranium*. In the membranous cranium, the blastema, immediately beyond the extremity of the chorda dorsalis, presents two thick bars, the *lateral trabeculæ* of Rathke, with a very thin part in the middle line between them, corresponding to the position of the pituitary body (see fig. 57, 4). These trabeculæ unite in front in the ethmoidal region, and it is to be remarked that in the cartilaginous stage the ethmo-vomerine cartilage or mesial septum of the nose is continued directly forwards from the region containing the chorda dorsalis. In the cartilaginous stage of the cranium the cartilage can only be traced in the basilar parts, and corresponds in extent to the occipital bone below the level of its protuberance, the petrous and mastoid portions of the temporal bone, the sphenoid and the ethmoid, while the part of the wall in which the frontal and parietal bones, the upper part of the occipital, and the squamous portions of the temporals appear, remains membranous. The extent, however, over which the cartilage of the primordial cranium extends differs in different animals, and is greater in many mammals than in man (Kölliker). The nasal bones are derived from the middle

frontal process, the superior maxillaries from the maxillary lobes, and the lachrymals probably from the lateral frontal lobes.

Fig. 57.

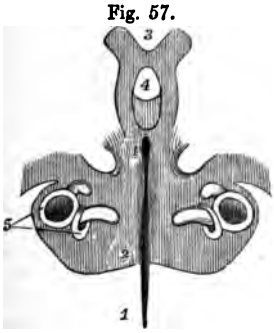


Fig. 57.—The Lower or Cartilaginous part of the Cranium of a Chick on the sixth day (from Huxley, Elements of Compar. Anat. Fig. 57, F').

1, 1, chorda dorsalis; 2, the shaded portion here and forwards is the cartilage of the base of the skull; at 2 the occipital part; at 3 the prolongations of cartilage into the anterior part of the skull called *trabeculæ cranii;* 4, the pituitary space; 5, parts of the labyrinth.

Formation of the face.—In studying the early development of the bones of the face it is necessary likewise to take into consideration the ossicles of the ear, viz., the malleus, incus, and stapes; for although in the adult these ossicles are so minute, and so entirely contained within the cavity of the tympanum that they have not been included in the description of the skull, they are importantly connected in their origin with a number of other bones. In each of the three first visceral arches a strip of firm tissue, which becomes cartilaginous, appears. That of the first arch is the most perfect, and is divided into three parts: the proximal part passes forwards some distance in contact with the basis cranii, it becomes ossified without passing through a cartilaginous stage, and from it are developed the palate bone and internal pterygoid plate; the middle part, which is very small, forms the body of the incus, and gives off two processes, the long and short processes of that ossicle; the remaining part, much the largest of the three, is prolonged downwards to meet its fellow of the opposite side at the extremity of the arch, and is named *Meckel's cartilage* after its first describer. (Meckel, "Handbuch der Mensch. Anat.") The upper extremity of Meckel's cartilage forms the malleus, the handle of which is developed as a process directed backwards. The lower portion is destined ultimately to dwindle away, but in the first instance increases in size, and forms a rod, on the external surface of which the lower jaw is formed. It can be detected on the internal aspect of the ramus of the jaw, up to the eighth month of fœtal life, but its only permanent vestige is the processus gracilis of the malleus, which, when the tympanic cavity becomes closed inferiorly by the growth of the tympanic plate, remains with its extremity fixed in the fissure of Glaser. The proximal extremity of the cartilage of the second visceral arch forms the stapes, and in succession downwards from this are found the stapedius muscle, the styloid process of the temporal bone, the stylo-hyoid ligament, and the small cornu of the hyoid bone. The only permanent portions of the cartilage of the third visceral arch are the great cornu and the body of the hyoid bone. (Reichert "Ueber

Fig. 58.

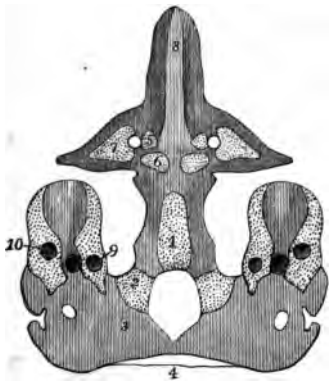


Fig. 58.—View from below of the Cartilaginous Base of the Cranium with its Ossific Centres of a Human Fœtus eight inches long (about five months, from Huxley, as before, Fig. 59, slightly altered, the bone being dotted to distinguish it from the cartilage, which is shaded with lines).

1, the basilar part, 2, the condyloid or lateral parts, and 3, 4, the tabular or superior part of the occipital surrounding the foramen magnum; 5, centres of the pre-sphenoid on the inside of the optic foramen; 6, centres of the post-sphenoid; 7, centres of the lesser wings or orbito-sphenoid; 8, septal cartilage of the nose; 9 & 10 parts of the labyrinth.

die Visceralbogen," Müller's Archiv, 1887. See for a figure of Meckel's cartilage the description of the ossicles of the ear.)

Ossification.—The *occipital* bone, for some time after birth, consists of four separate pieces, a basilar, a tabular, and two condyloid parts. The lines of junction of the basilar and condyloid parts pass through the condyles near their anterior extremities; those of the condyloid and tabular parts extend outwards from the posterior extremity of the foramen magnum. The basilar and condyloid parts arise each from one osseous nucleus. In the tabular part there are probably in most cases four nuclei, placed in pairs above and below the occipital protuberance: Meckel mentions four additional nuclei, placed two at the superior and one at each lateral angle ("Handbuch der Mensch. Anat.," ii. § 543); the different nuclei speedily unite to form a single thin tabular mass.

Fig. 59.

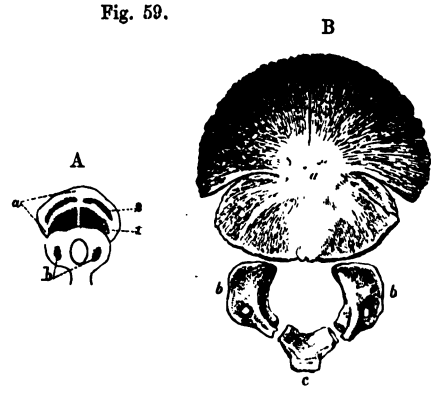


Fig. 59.—Ossification of the Occipital Bone.

A, in a fœtus of 10 weeks (from Meckel, Archiv, vol. i. tab. vi.); *a*, upper or tabular part; 1 & 2, lower and upper pairs of ossific centres in it; *b*, lower part or basilar and condyloid portions: ossific centres are seen in the condyloid portions.

B, occipital bone of a child at birth; *a*, upper or tabular part, in which the four centres have become united into one, leaving fissures between them; *b*, *b*, the ossified condyloid portions; *c*, the basilar portion.

The *parietal* bones are ossified each from one nucleus which is placed near the centre of the bone or at the parietal eminence.

The *frontal* bone consists for a year, or from one to two years after birth, of two lateral portions, which not unfrequently remain separate during life (as happens also in the majority of animals), with a vertical suture between them, the *frontal suture*. Ossification begins on each side from a single nucleus above the orbit, or in the place of the frontal eminence.

Fig. 60.

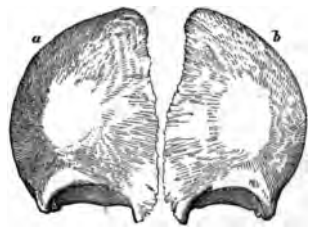


Fig. 60.—Frontal Bone of a Fœtus shortly before Birth.

a & *b* indicate the two separate portions of the bone, in each of which the radiation of bony spicula from the frontal eminence is seen.

The *Fontanelles*. Opposite the angles of the parietal bones, there are spaces which remain unoccupied by bone, after the osseous wall of the skull is elsewhere completed. Two of these, the *anterior* and *posterior fontanelles*, are in the middle line; the *lateral fontanelles*, two on each side, are opposite the inferior angles of the parietal bones, and are less important. The anterior fontanelle, situated between the adjacent angles of the parietal bones and the ununited halves of the frontal bone, is quadrangular in form, and remains open for some time after birth. The posterior fontanelle, situated between the parietal bones and the superior angle of the occipital bone, is triangular; it is filled up before birth, but during parturition the compression of the child's head forces the angle of the occipital bone beneath the edges of the parietals,

and produces a triangular depression at the site of the posterior fontanelle, which is easily recognised by the finger of the accoucheur.

The *temporal* bone, considered in respect of its development, consists of the squamous and petro-mastoid parts, the tympanic plate, and the styloid process. The squamous part, inclusive of the zygomatic process, is ossified from a single nucleus. The petrous and mastoid portions are also formed from only one centre: bone is first deposited on the anterior surface, over the cochlea, and there afterwards appear one or two nuclei on the posterior surface, in connection with the formation of the semicircular canals; the different nuclei soon unite, and ossification extends into the mastoid process. The tympanic plate appears in the membranous wall of the tympanum and external ear as a slender arch of bone forming three-fourths of a ring, inclosing the membrana tympani. The styloid process is formed, as already stated, in the second visceral arch.

Fig. 61.

Fig. 61.—Separate parts of the Temporal Bone of a Child at Birth.

a, squamous part with the zygoma; *b*, the tympanic bone forming an imperfect ring open superiorly; *c*, the petrous and mastoid part; *c* being placed on the mastoid part: part of the cavity shown is the tympanum.

The *sphenoid* bone presents in infancy traces of a natural division into a posterior or *post-sphenoid* part, to which the sella turcica and great wings belong, and an anterior or *pre-sphenoid* part, to which belong the body in front of the olivary process and the small wings,—a division which is found in many animals complete and persistent through life. The first osseous nuclei of the post-sphenoid division occur in the great wings, one on each side, between the foramen rotundum and foramen ovale, and spread thence outwards into the wing and downwards into the external pterygoid process. The internal pterygoid processes arise from distinct nuclei, and, although in the human subject they soon unite with the external pterygoid, in other animals they remain separate, and are named by comparative anatomists the *pterygoid bones*.

Fig. 62.

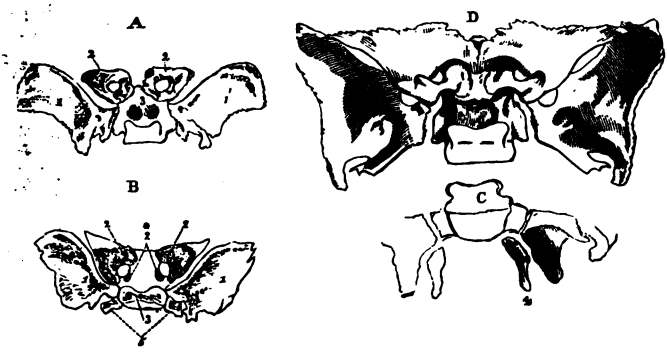


Fig. 62.—Ossification of the Sphenoid Bone.

A, sphenoid bone from a fœtus of three months, seen from above; 1, 1′, the greater wings ossified; 2, 2, the lesser wings, in which the ossification has encircled the optic foramen, and a small suture is distinguishable at its posterior and inner side; 3, two round granules of bones in the body below the sella turcica, the rest being cartilaginous.

B, copied from Meckel (Archiv, vol. i. tab. vi. fig. 23), and stated to be from a fœtus

of six months; 2*, additional nuclei for the lesser wings; 5, separate lateral processes of the body: the other indications are the same as in A.

C, sketch of the back part of the bone shown in A; 4, the internal pterygoid processes still separate.

D, the sphenoid at the usual period of birth. The great wings are still separate. The anterior sphenoid is now joined to the body, and the internal pterygoid processes (not seen in the figure) are united to the external.

In the post-sphenoid part of the body two granules appear, placed side by side in the sella turcica, and after their union two others appear, from which are formed the parts on which are placed the carotid grooves. In the pre-sphenoid division the first pair of nuclei appear outside the optic foramina, and extend by their growth into the small wings: another pair of granules appear on the inner sides of the foramina, and the pre-sphenoid portion of the body either results from the union of these, or is an independent growth. The pre-sphenoid is united to the body of the post-sphenoid long before the latter is united to the great wings. Their line of union is indicated for some time by a hole filled with cartilage, round above, and opening inferiorly into a wide notch, which is recognisable for several years after birth. The body of the pre-sphenoid is for a year or two broad and rounded inferiorly, but becomes gradually narrower and more prominent: it is separated at first by a layer of fibro-cartilage from the sphenoidal spongy bones. The *sphenoidal spongy bones* seldom appear till after birth: each is in early life a hollow pyramid formed by the union of three separate laminæ, viz., an inferior, an external, and a superior: the inferior lamina forms the greater part of what can be distinguished in the adult; the external is that to which the orbital portion belongs; while the superior lamina, forming the inner wall and roof of the original sphenoidal sinus, becomes, as the sinus expands, partly absorbed and partly united to the attenuated body of the pre-sphenoid, which is ultimately reduced to the thin septum sphenoidale and the rostrum.

The *ethmoid* bone exhibits osseous deposit first in the orbital plates, whence it spreads into the turbinated portions; in its mesial part ossification begins above and passes down into the nasal septum, and outwards into the cribriform plate.

The *superior maxillary* bone commences to ossify at a very early period—immediately after the lower maxilla and the clavicle, and before the vertebræ. Its early growth has not yet been sufficiently studied. Béclard (Meckel's Archiv., vi. p. 432)

Fig. 63.

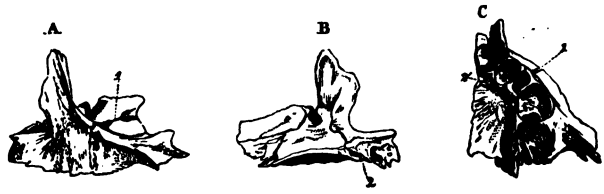


Fig. 63.—Different views of the Superior Maxillary Bone of a Fœtus of four or five months.

A, external surface; a fissure, 1, is seen extending through the orbit into the infra-orbital foramen.

B, the internal surface; the incisor fissure, 2, extends from the foramen upwards through the horizontal plate and some way into the nasal process.

C, the bone from below, showing the imperfect alveoli and the incisor fissure, 2′, 1, which crosses the palatine plate, between the second and third alveolus, and passes through the outer part of the bone.

states that it consists at first of five pieces, viz., 1, an alveolar arch; 2, a palatal part; 3, an orbital and malar; 4, a nasal and facial; 5, an incisor part. This, however, does not appear to be a constant arrangement. In all young subjects, and sometimes even in the adult, there is a fissure, the *incisor fissure*, passing outwards from the incisor foramen to the alveolar border, in front of the canine socket. The part in

front of this fissure—namely, that which bears the incisor teeth—forms in all mammals except man a separate bone, the *intermaxillary* or *premaxillary;* and anatomists have therefore sought with great care for proofs of its original independence in the human subject, but it does not appear that even in the earliest stages of development it has been seen by any one entirely unattached to the rest of the bone, or that its line of suture has been traced upon the facial surface. On the other hand, in cases of completely cleft palate, the bones supporting the incisor teeth are placed on a projecting portion of bone, which is articulated to the fore part of the vomer, and is entirely detached from the superior maxillary bones.

The *palate* bone is formed from a single centre, which is deposited at the angle between its horizontal and ascending parts.

Fig. 64.

Fig. 64.—The Fœtal Vomer near the time of birth.

1 & 2 show the two plates of which the bone consists, and which are united behind and below.

The *vomer* begins to ossify posteriorly near the upper part. It consists at first of two laminæ united posteriorly and inferiorly. The inferior border afterwards exhibits a flat surface marked by a mesial line, which articulates with the maxillary and palate bones and ends abruptly behind the crista nasalis. The margins of this surface become gradually absorbed. The appearance of a mesial plate does not take place for a little time after birth.

The *malar, nasal, lachrymal,* and *inferior turbinated bones* are each ossified from a single centre.

Fig 65.

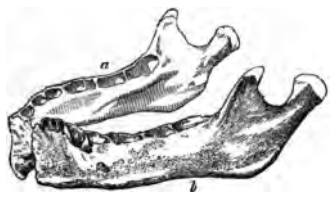


Fig. 65. — The Inferior Maxilla of a Child at birth.

a & *b* indicate the two portions separate at the symphysis.

The *inferior maxilla* begins to ossify before any other bone except the clavicle. It consists of two equal lateral parts, which are still separate at the time of birth. The ossific matter is at first deposited in fibrous tissue, and later in cartilage. Some observers admit only a single ossific centre for each side (Nesbitt and Meckel); while, according to others, in addition to the main piece there are separate nuclei for the coronoid process, the condyle, the angle, and the inner side of the alveolus (Spix), or only for some of these parts (Kerckringius, Béclard, Cruveilhier). The dental canal is at first a simple open groove. As in the superior maxilla the alveoli are gradually developed from the groove by its division into compartments by partitions of subsequent growth.

The *hyoid* bone has five points of ossification—one for the body, and one for each of its great and small cornua. The ossification begins in the great cornua, and soon follows in the body in the last month of fœtal life.

PERIODS OF OSSIFICATION OF THE BONES OF THE SKULL.

In the occipital bone—

Ossification of the tabular part appears in the 7th week (fœtal life).
Ossification of the basilar part appears in the 7th or 8th week.
Ossification of the condyloid part appears in the 7th or 8th week.
The condyloid and tabular parts unite in the 4th year.
The basilar and condyloid parts unite in the 5th or 6th year.

In the parietal bone ossification appears in the 7th or 8th week.

In the frontal bone ossification appears in the 7th week.

The parts of the frontal bone unite in the course of the 2nd year.

In the temporal bones—
- Ossification of the squamous part appears in the 7th or 8th week.
- Ossification of the petro-mastoid part appears in the 4th month.
- Ossification of the ossicula auditus appears in the 4th month.
- Ossification of the tympanic ring appears in the 3rd month.
- Ossification of the styloid process appears after puberty.
- The squamous, petro-mastoid, and tympanic parts unite in the 1st year.

In the sphenoid bone—
- Ossification of the great wings appears in the 8th week.
- Ossification of the posterior part of the body appears in the 8th or 9th week.
- Ossification of the internal pterygoid processes appears in the 4th month.
- Ossification of the anterior part of the body, including the small wings, appears in the 8th or 9th week.
- Ossification of the sphenoidal spongy bones appears about the time of birth.
- The centres of the posterior part of the body unite in the 4th month.
- The internal and external pterygoid processes unite in the 5th or 6th month.
- The anterior and posterior parts of the body unite in the 8th month.
- The body and great wings unite in the 1st year.
- The sphenoidal spongy bones and the body unite about the age of puberty.

In the ethmoid bone—
- Ossification of the lateral masses appears in the 4th or 5th month.
- Ossification of the vertical and cribriform plates appears in the 1st year.

In the superior maxillary bones ossification appears in the 6th or 7th week.

In the palate, vomer, nasal, and malar bones ossification appears in the 7th or 8th week.

In the lachrymal bones ossification appears in the 8th week.

In the inferior turbinated bones ossification appears in the 5th month.

In the inferior maxillary bone ossification appears in the 6th week.
- The two parts of the inferior maxillary bone unite in the 1st year.

In the hyoid bone—
- Ossification of the body and great cornua appears before birth.
- Ossification of the small cornua appears in the 1st year.

THE VERTEBRAL THEORY OF THE SKULL.

The idea that the skull is composed of a series of vertebræ, whose arches are expanded and united to enclose and protect the encephalon, appears to have originated with Goethe in 1791, but occurred independently to Oken, and was first published by him in 1807. Since then many conflicting theories have been brought forward on the subject by different anatomists, who have estimated the cranial vertebræ at numbers varying from three to seven; while by others the idea has been entirely rejected, and even the possibility of referring the bones of the skull to distinct segments denied. Some of the facts in favour of the vertebral theory are sufficiently manifest. Thus, the basilar process of the occipital bone, and the mesial parts of the post-sphenoid and pre-sphenoid bones, lie in series with and bear considerable resemblance to the centra or bodies of vertebræ, as is seen particularly in those animals in which the pre-sphenoid and post-sphenoid bones remain distinct: the visceral arches of the embryo likewise form a series: in the roof of the skull a certain degree of repetition of parts from behind forwards is also visible, especially in some of the lower animals: the mode of formation of the head and of the trunk is almost the same up to the time when the primordial vertebræ appear in the latter: and lastly, the general resemblance of the occipital bone to a vertebra is admitted by all. On the other hand, as it must be allowed that there is no original division of the cartilaginous basis of the cranium, in that part of it which lies in front of the sphenoid bone, and to which the chorda dorsalis does not penetrate, it is not easy to trace a resemblance to vertebral form; and in the face it is still more difficult to demonstrate in the several parts a definite arrangement of visceral or costal arches. Deterred by the differences of opinion with respect to the number of cranial segments and the bones which belong to each, some may be inclined to set aside the discussion entirely, but we must not too rashly decide against the existence of such segmentation, nor forget that some correspondence

between several bones of the skull and vertebræ in man and animals is generally admitted by scientific anatomists, and that the difficulties which oppose the enunciation of clearer views on the serial relations of the cranial elements arise in great measure from deficient information and want of agreement among anatomists as to individual points in the correspondence of those elements throughout the animal series. (See, in addition to the works previously referred to, Huxley, "Elements of Comparative Anatomy," 1864; Cleland, "On the Relations of the Vomer," &c., Trans. Roy. Soc. 1862; Spix, "Cephalogenesis," 1815; Von Baer, "Entwickelungsgesch. der Thiere," 1828—37; Hallman, "Die Vergleich. Anat. des Schläfenbeins," 1837; Bojanus in Isis, 1818—1819.)

THE VARIOUS FORMS OF THE SKULL.

I. *Differences according to Age.*—In the earlier stages of its development the posterior part of the skull bears a very large proportion to the anterior part; so much so, that in the second month of fœtal life the line of the tentorium cerebelli is vertical to the basis cranii, and divides the cranial cavity almost equally into two parts. At the time of birth the parietal region has reached its largest development in proportion to the occipital and frontal regions. The greatest frontal breadth is then smaller in proportion to that between the parietal eminences than afterwards. In the first years of childhood the superior parts of the skull grow more rapidly than the base. Thus, in the frontal region, the upper part of the frontal bone grows more rapidly than its orbital processes, giving the prominent appearance of the frontal eminences peculiar to children. The face at birth is calculated as being scarcely an eighth of the bulk of the rest of the head, while in the adult it is at least a half (Froriep, "Characteristik des Kopfes nach dem Entwicklungsgesetz desselben"). In harmony with the growth of the face the lower part of the forehead is brought forward by elongation of the anterior cranial fossa, and on the approach of adult age it becomes in the male still more prominent by the expansion of the frontal sinuses. The face becomes elongated in the progress of growth, partly by increased height of the nasal fossæ, partly by the growth of the teeth and the enlargement of the alveolar arches of the jaws. In old age the proportion of the face to the cranium is diminished by the loss of the teeth and absorption of the alveolar portions of the jaws. In consequence of this the upper jaw retreats, while in the lower jaw the same cause gives, especially when the mouth is closed, a greater seeming prominence to the chin.

II. *Sexual Differences.*—The female skull is, in general, smaller, lighter, and smoother than that of the male; it is less marked by muscular prominences, and has also the frontal sinus less developed. The face is smaller in proportion to the cranium, the jaws narrower, and the frontal and occipital regions less capacious in proportion to the parietal. (Huschke.) The female skull resembles the formed skull of the boy more than that of the adult male; but it must also be admitted that it is often impossible to determine the sex by the appearance or form of a skull.

III. *National Differences.*—That characteristic forms of skull are presented by the various races of men has probably been long known, but was first distinctly pointed out by Camper. Subsequently the investigations of Blumenbach raised the study of those different forms to a recognised position in ethnology. The extent and constancy of the ethnical differences of skulls are matters open to discussion; but it must be allowed, that although many skulls are to be met with which fail to exhibit the characteristics of the race to which they belong, or which present peculiarities similar to those of nations considerably removed from them, yet not only are there certain forms of skull highly distinctive of the principal varieties of mankind, but the prevailing form in one nation is often very distinguishable from those found in nations inhabiting neighbouring countries. Great differences occur with respect to size in the skulls of different nations. Among the smallest skulls may be mentioned those of the Hindoo and ancient Peruvian; among the most massive those of the Scandinavian, the Caffre, and the Maori. Various characters are found belonging to the skulls of rude tribes, which serve to distinguish them from those of civilised nations. Among those characters may be mentioned,—a depressed appearance between the middle line of the calvarium and the temporal ridge, both of which stand out prominently, making the roof of the skull seem like a house top; a greater width of the zygomatic arches, and of the anterior nares; greater strength of the jaws and teeth,

and especially projection forwards of the incisors, so that those of the upper meet those of the lower jaw at an angle, instead of both sets being nearly perpendicular as in cultivated nations. Elongation of the face downwards may be regarded as a specially human characteristic connected with the use of voice and speech, but projection of the jaws forwards is only advantageous for the seizure of food, and gives an appearance of approach to the still further projected form of the jaws in the lower animals, particularly when accompanied, as it often is, by deficient development of the chin.

The degree of projection of the face in different races of men, and its prominence and increased proportion to the cranium in the lower animals, Camper proposed to express by the angle contained between two lines, one of them descending from the most prominent part of the forehead to the incisor margin of the upper jaw, the other passing through the meatus auditorius externus and the nasal spine: this he termed the *facial angle*. He estimated its maximum in the European adult at 80°, and in the skull of a young negro he found it diminished to 70°; while in antique works of art he pointed out that it was increased for artistic effect to 90° or more, an extent never realised in nature. In animals, the facial angle is always much lower than in man. According to Camper and Lawrence, it reaches in the young orang as high a point as 56° or 60°; but in the adult orang they found it attaining only to 47°, while Owen finds it to be as low as 30°. (Owen, "Zoolog. Trans.," vol. i. p. 373.) Several modifications of Camper's angle have been suggested; but, like it, they all labour under the disadvantage of being subject to modification from other peculiarities besides the relations proposed to be estimated.

A convenient method of comparing the skulls of different races was introduced by Blumenbach, and has been much employed,—the *norma verticalis*, or examination of the skull by looking perpendicularly down upon it, which exhibits in one view the proportionate length and breadth of the cranium, the projection of the jaw beyond the forehead, and the lateral prominence of the zygomatic arches. In addition to the norma verticalis and profile view, Prichard has likewise employed the front view in examining skulls, showing that, whereas in well-formed European heads, lines drawn from the zygomatic arch and touching the temples are parallel, the same lines in the skulls of Esquimaux and others meet over the forehead, and form with the basis a triangular figure.

More recently, a classification of skulls has been made by Retzius, which has met with considerable acceptance. According to his arrangement, they may be primarily divided into the *dolichocephalic*, or those which are elongated from before backwards, and the *brachycephalic*, or those which have nearly as great breadth as they have length. In each of those divisions are distinguished the *prognathous* skulls, or those in which the upper jaw is visible when they are examined by the norma verticalis, and the *orthognathous*, in which the jaw is overhung by the forehead. The nations of Western Europe present the orthognathous dolichocephalic type of skull; the African negro the prognathous dolichocephalic type; the Slavonic nations exhibit the orthognathous brachycephalic type; the Mongolians the prognathous brachycephalic. (Camper, "On the Connection between Anatomy, Drawing, &c.," transl. by Cogan, 1794; Blumenbach, "Institutions of Physiology," by Elliotson, 1820; and "De Generis Humani Varietate Nativâ," 1795; Prichard, "Researches into the Physical History of Mankind," and "Natural History of Man;" Morton, "Crania Americana;" Thurnam and Davies, "Crana Britannica;" Huschke, "Schädel, Hirn, und Seele des Menschen und der Thiere, &c.," 1854; Meigs, "Cranial Characteristics of the Races of Men," Philad. 1857; Retzius, "On the present State of Ethnology with reference to the Form of the Skull," translated in Brit. and For. Medico-Chir. Review, April & July, 1860; Carpenter, in "Cyclop. of Anat. and Physiol.")

IV. *Irregularities of Form.*—The most frequent irregularity in the form of the skull is want of symmetry. This sometimes occurs in a marked degree, and there is probably no skull perfectly symmetrical. The condition which has been observed to co-exist most frequently with irregular forms of skull is *synostosis*, or premature obliteration of certain of the sutures. The cranial bones increase in size principally at their margins; and when a suture is prematurely obliterated, the growth of the skull in the direction at right angles to the line of suture may be supposed to be checked, and increased growth in other directions may take place to supply the defect.

(For an account of the varieties of form thus produced, see Virchow, "Gesammelte Abhandlungen," 1856.) Another series of irregular forms of skull is that produced by pressure artificially applied in early life, and is best exemplified from among those American tribes who compress the heads of their children by means of an apparatus of boards and bandages: it is also illustrated in a slighter degree by individual instances in which undue pressure has been employed unintentionally. (Gosse, "Essai sur les Déformations artificielles du Crane," 1855.) Posthumous distortions likewise occur in long-buried skulls, subjected to the combined influence of pressure and moisture. (Wilson, "Prehistoric Annals of Scotland.")

IV.—BONES OF THE UPPER LIMB.

The superior extremity, or upper limb, consists of the shoulder, the arm, the fore arm, and the hand. The bones of the shoulder are the scapula and clavicle; in the arm is the humerus; in the fore arm are the radius and ulna; and in the hand three groups of bones, the carpus, metacarpus, and digital phalanges.

SCAPULA.

This bone is placed upon the upper and back part of the thorax, occupies the space from the second to the seventh rib, and forms the posterior part of the shoulder.

It is attached directly to the trunk only by the clavicle, and from it is suspended the humerus.

It is of an irregular triangular form, flat in the greater part of its extent, and elongated downwards; and is so placed, that its internal border is likewise posterior. Its angles may be termed superior, inferior, and external.

It has an anterior and posterior surface, and presents at its external angle the *head* with its *glenoid* cavity or articular surface for the humerus, supported on a short thick *neck* of bone, and surmounted by the *coracoid* process; also, springing from its posterior surface, the *spine* terminating in the *acromion* process.

The *anterior surface* exhibits in the greater part of its extent a shallow concavity, the *fossa subscapularis* or *venter*, occupied by the subscapularis muscle, and marked by irregular prominent lines converging upwards and outwards, which give attachment to the tendinous intersections of that muscle. Separated, however, from this concavity, there are several smaller flat spaces: one is a triangular surface in front of the superior angle, another is a smaller surface at the inferior angle, and these, together with a rough line running close to the posterior border and uniting them, give attachment to the serratus magnus muscle: there is also a grooved area occupied by the lower border of the subscapularis muscle, close to the external border, and separated from the fossa subscapularis by a prominent ridge descending from the neck of the bone.

The *posterior surface* or *dorsum* is divided by the spine into two unequal parts, the superior and smaller of which is called *fossa supra-spinata*, the inferior *fossa infra-spinata*. The supra-spinous fossa has its greatest vertical extent at its internal extremity, but is deepest externally: it is occupied by the supra-spinatus muscle. The infra-spinous fossa, much larger than the preceding, presents in the middle a convexity corresponding to the concavity of the venter, and outside this a concavity bounded by the prominent external border. It is marked near the inner border by short lines, corresponding to tendinous septa of the infra-spinatus muscle, and is occupied by that muscle in the greater part of its extent. Adjacent to the external border, in its middle third, is a narrow interval giving attachment to the

teres minor muscle ; and beneath this, extending over the inferior angle, is a raised oval surface, from which the teres major arises. These spaces are separated from that of the infra-spinatus muscle by a rough line, which gives attachment to an aponeurotic septum.

The *spine* of the scapula is a massive plate of bone projecting backwards from the dorsum, and curving slightly upwards. It extends outwards and

Fig. 66. Fig. 67.

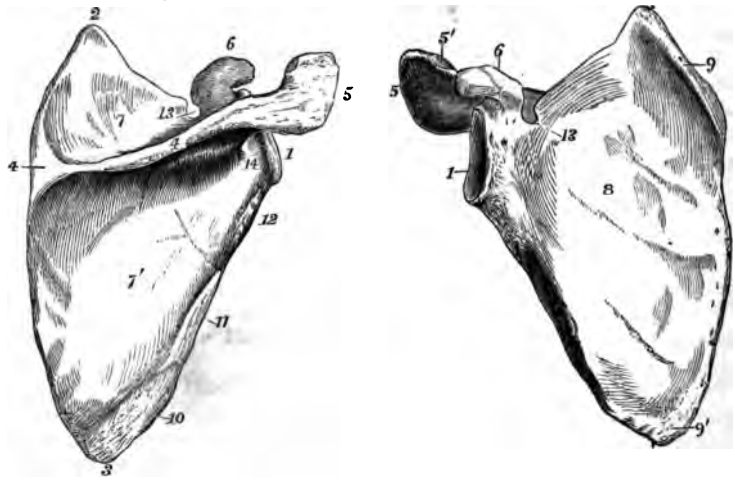


Fig. 66.—Right Scapula from behind. $\frac{1}{3}$

1, glenoid head ; 2, superior angle ; 3, inferior angle ; 4, spine ; 4, at the base, points by a line to the triangular smooth surface of the spine ; 5, acromion ; 6, coracoid process ; 7, supraspinous fossa ; 7′, infraspinous fossa ; 1 to 2, superior border ; 2 to 3, posterior border or base ; 1 to 3, external or inferior border ; 10, is opposite the oval surface of origin of the teres major muscle ; 11, the oblique groove where the teres minor muscle rises ; 12, the rough ridge where the long head of the triceps rises ; 13, supra-scapular notch ; 14, is below the great scapular notch.

Fig. 67.—Right Scapula from before. $\frac{1}{3}$

1, 5, 6, & 13, as in fig. 66 ; 5′, articular facet on the acromion for the clavicle ; 8, subscapular fossa ; 9, long, narrow surface, and 9′, triangular rough surface, separated from the subscapular fossa and giving attachment to the upper and lower parts of the serratus magnus muscle.

a little upwards from the internal border near its upper fourth, towards the middle of the neck, and becoming gradually elevated towards its external extremity, it turns forwards and is continued into the acromion process. The upper and lower surfaces are smooth, of a triangular form, concave, and form part respectively of the supraspinous and infraspinous fossæ. It presents two unattached borders, the most prominent of which arises from the internal border of the bone by a smooth, flat, triangular surface, on which the tendon of the inferior part of the trapezius muscle glides, as it passes to be inserted into a rough thickening beyond, which projects slightly downwards. In the rest of its extent this border is rough, broad, and subcutaneous, giving attachment by its superior margin to the trapezius, and by its inferior to the deltoid muscle. The other, the external border, short, smooth, and concave, arises near the neck of the scapula, and is continuous with the under surface of the acromion, surrounding thus the *great scapular notch* between the spine and the neck of the bone.

The *acromion process*, projecting outwards and forwards from the extremity of the spine, is situated above and behind the glenoid cavity, and forms the summit of the shoulder. It is an expanded process, compressed from above downwards. Its superior surface, rough and subcutaneous, is continuous with the prominent border of the spine; its inferior surface, smooth and concave, is continuous with the superior surface and external border of the spine. On its internal border anteriorly is a narrow oval surface for articulation with the clavicle; and at its extremity it affords attachment to the coraco-acromial ligament.

The *glenoid cavity* is a slightly concave surface, looking outwards and a little upwards and forwards. It is ovoid or rather pyriform in shape, with the narrow end uppermost, and gently incurved in front. It is in some degree flattened at its circumference, where, in the recent state, it is covered by a fibrous band, the glenoid ligament, which deepens its concavity; and at its upper extremity is a slight roughness, marking the attachment of the long head of the biceps muscle.

The *neck*, supporting the glenoid cavity, is most distinct posteriorly, where it forms between the glenoid cavity and the spine the *great scapular notch* or *groove*, leading from the supraspinous to the infraspinous fossa. The line of the neck, as described by anatomists, passes superiorly between the glenoid cavity and the coracoid process, but that of the part often named neck by surgeons passes internal to the coracoid process.

The *coracoid process*, thick and strong, springs almost vertically from the superior border of the bone, above the glenoid cavity, but, suddenly bending at a right angle, is directed forwards and outwards. Its superior surface, towards the base, is rough and uneven, giving origin to the coraco-clavicular ligaments; on its outer border is attached the coraco-acromial ligament, at its extremity the coraco-brachialis muscle and short head of the biceps, and on the inner edge the pectoralis minor.

The *borders* or *costæ* of the scapula are three in number. The *superior* border is the shortest; it extends from the superior angle outwards and downwards towards the coracoid process, at the base of which it presents a rounded *suprascapular notch* (*incisura semilunaris*), which is converted into a foramen by a ligament or occasionally a spiculum of bone, and is traversed by the suprascapular nerve, and sometimes also by the accompanying vessels. The *external*, *axillary*, or *inferior* border presents at its upper part, beneath the glenoid cavity, a rough tuberculated ridge, above an inch long, to which the long head of the triceps muscle is attached: a little below this there is usually a slight groove, where the dorsal branch of the subscapular artery passes backwards: and at its lower extremity the border is thick, and rounded over into the space from which the teres major muscle arises. The *internal*, *vertebral*, or *posterior* border, called also the base, is the longest of the three, and is divisible into three parts, viz., a short one opposite the triangular surface of origin of the prominent border of the spine, and the portions above and below that space, both of which incline outwards as they recede from the spine. The upper part gives attachment to the levator anguli scapulæ muscle, the middle one to the rhomboideus minor, and the lower to the rhomboideus major muscle.

Texture.—The triangular part of the scapula is in great part thin and translucent, and contains little cancellated tissue. The neck, the coracoid and acromion processes, the prominent border of the spine, and the part near the inferior angle, derive their greater thickness and strength from increased thickness of the compact bony substance in some parts, and

from cancellated tissue in others. A vascular foramen usually pierces the inferior surface of the spine, and others are to be found on the anterior surface of the bone, near the neck.

THE CLAVICLE.

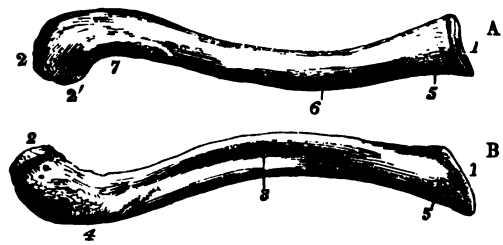
The clavicle or collar bone extends transversely outwards, with an inclination backwards, from the summit of the sternum to the acromion process of the scapula, and connects the upper limb with the trunk.

It is curved somewhat like an italic *f*: the convexity of the internal curve is directed forwards, and extends over two-thirds of the length of the bone; that of the outer curve looks backwards, and is most marked near the outer fourth of the bone.

The clavicle, towards its scapular end, is compressed and broad from above downwards, but in the extent of its inner curve it is more or less prismatic or cylindrical. In its description, four surfaces of the shaft may be distinguished, together with the two extremities.

Fig. 68.—The Right Clavicle. ½

Fig. 68.



A, from above; B, from below.

1, sternal end; 2, acromial end; 2′, small facet for articulation with the acromion; 3, groove on the lower surface for the subclavius muscle; 4, rough elevation at the place of attachment of the coraco-clavicular ligaments; 5, rough depression at the place of attachment of the costo-clavicular or rhomboid ligament; 6, in front, the mark of the attachment of the pectoralis major; 7, that of the deltoid muscle.

The *superior surface* is broadest in its outer part; it is principally subcutaneous, but near the inner extremity presents a slight roughness, marking the clavicular attachment of the sterno-cleido-mastoid muscle. The *anterior surface* opposite the outer curve is a mere rough border, from which the deltoid muscle takes origin, but in the inner half of its extent is broadened out into an uneven space more or less distinctly separated from the inferior surface, and giving attachment to the pectoralis major muscle. The *posterior surface* is broadest at the inner extremity, and smooth in the whole extent of the internal curvature; but towards its outer extremity it forms a narrow rough border which separates it from the superior surface, and gives attachment to the trapezius muscle. On the *inferior surface* an elongated roughness near the scapular extremity marks the attachment of the coraco-clavicular ligaments; extending inwards from this, over the middle third of the bone, is a groove in which the subclavius muscle is inserted; and near the sternal end is a smaller rough depression, to which the costo-clavicular ligament is attached.

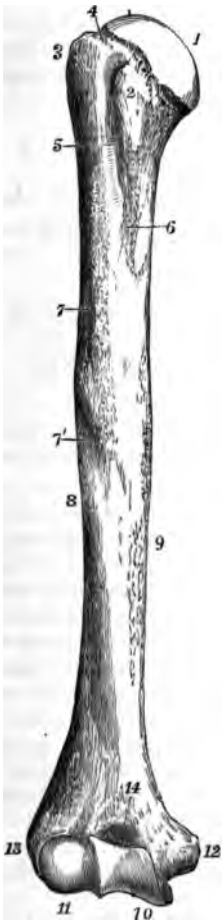
The *internal extremity* is the thickest part of the clavicle. It presents a somewhat variably concavo-convex surface, somewhat triangular in form, with its most prominent angle directed downwards and backwards. The compressed *external extremity* is convex from before backwards, and articulates by a small oval surface with the acromion.

Texture.—The interior of the clavicle contains coarse cancellated tissue in its whole extent. It almost always presents a foramen for a medullary artery on its posterior surface, and sometimes others.

THE HUMERUS.

The humerus or arm bone extends from the scapula to the bones of the forearm, with each of which it is articulated. It hangs nearly vertically from the shoulder, with an inclination inwards towards the lower end. It is divisible into a superior extremity, including the head, neck, and greater and smaller tuberosities; the shaft; and the inferior extremity, including the external and internal supracondyloid eminences, and the inferior articular surface. In general form it is subcylindrical and slightly twisted.

Fig. 69.



The *superior extremity* is the thickest part of the bone. The *head* is a large hemispherical articular elevation, directed inwards, upwards, and somewhat backwards. The *neck*, as described by anatomists, is the ring of bone which supports the head; inferiorly, it passes into the shaft; superiorly, it is a mere groove between the head and the great tuberosity. The *neck*, as often described by surgeons, is the part of the shaft immediately below the tuberosities. The *great tuberosity* is a thick projection, continued upwards from the external part of the shaft, and reaching nearly to the level of the upper margin of the head; it is surmounted by three flat surfaces, the uppermost of which gives attachment to the supra-spinatus muscle, the lowest to the teres minor, and the intermediate one to the infra-spinatus muscle. Separated from the great tuberosity by the commencement of the bicipital groove, the *small tuberosity*, rounded and prominent, looks directly forwards and gives attachment to the subscapularis muscle.

Fig. 69.—RIGHT HUMERUS FROM BEFORE. $\frac{1}{5}$

1, the articular head; 2, lesser tuberosity; 3, greater tuberosity; 4, neck of anatomists; 5, bicipital groove; 6, inner bicipital ridge, and mark of the attachment of the latissimus dorsi and teres major muscles; 7, outer bicipital ridge, and rough surface of insertion of the pectoralis major, running down into 7', the triangular mark of the insertion of the deltoid; 8, spiral groove; 9, inner ridge of the humerus; 10, trochlear articular surface; 11, capitellum, or radial condyle; 12, epitrochlear or internal supracondyloid eminence; 13, capitellar or external supracondyloid eminence; 14, coronoid depression or fossa.

The *shaft* or *body*, thick and cylindrical superiorly, becomes somewhat thinner as it descends, and in the lower third is expanded transversely and becomes somewhat three-sided. Superiorly on its anterior aspect is the bicipital groove, so named from lodging the long

tendon of the biceps muscle: this groove, commencing between the tuberosities, descends with an inclination inwards, and is bounded by two rough ridges, the external and most prominent of which gives attachment to the pectoralis major muscle, the internal or posterior to the latissimus dorsi and teres major. Towards the middle of the shaft, on the inner lateral line, is a rough linear mark where the coraco-brachialis muscle is inserted, and lower down there is a medullary foramen directed downwards into the interior of the bone. On the external part of the shaft, near its middle, in a line anteriorly with the external bicipital ridge, is a large, rough, and uneven surface, of a triangular shape, the *impression of the deltoid muscle*. Below this the external bicipital ridge is continued into a smooth elevation which, descending on the front of the shaft to the inferior extremity, separates an external from an internal surface, while at the sides two sharp edges, the *external* and *internal supracondyloid ridges* spring from the eminences of the same name and ascend for some distance, separating the anterior from the flat posterior surface. About the middle of the shaft externally, a broad depression, the *musculo-spinal groove*, passes downwards and forwards in a spiral direction, limited above by the deltoid impression and below by the external supracondyloid ridge, and lodges the musculo-spiral nerve and the accompanying artery.

Fig. 70.

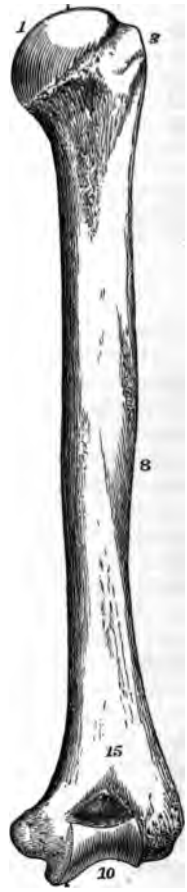


Fig. 70.—Right Humerus from behind.

1, 3, 8, & 10, the same as in Fig. 69; 15, is placed above the olecranon fossa.

The *inferior extremity* is much enlarged laterally, flattened from before backwards, and is curved slightly forwards. Projecting on either side are the *external* and *internal supracondyloid eminences* (the *condyles* of most authors, *epicondyle* and *epitrochlea* of Chaussier), the internal of which is much more prominent than the external, and is slightly inclined backwards. The *inferior articular surface*, fitting by peculiar curved grooves and eminences to the corresponding surfaces of the radius and ulna, is divided by a ridge into an external and an internal part. The external part, articulated with the radius, consists of a rounded eminence directed forwards, called the *capitellum*, and a groove internal to it; it does not extend to the posterior surface. The internal part, the *trochlea*, articulates with the ulna, and extends completely round from the anterior to the posterior surface of the bone; it is grooved down the middle like the surface of a pulley, and is somewhat broader behind than in front; anteriorly, its margins are inclined downwards and inwards; posteriorly, upwards and outwards, and so that seen from behind, it lies in the middle part of the bone. Anteriorly, the internal margin of the trochlea is the most prominent, and widens below into a convexity parallel to the groove; posteriorly, the external margin is most

prominent. Above the trochlea posteriorly is a large and deep pit, the *olecranon fossa*, which receives the olecranon process of the ulna in extension of the forearm; and above it anteriorly, separated from the olecranon fossa only by a thin lamina of bone, is the much smaller *coronoid fossa* which receives the coronoid process in flexion. Above the capitellum is a shallow depression, into which the head of the radius is pressed in complete flexion.

Varieties.—It is not uncommon to find a small hooklike process, with its point directed downwards, placed in front of the internal supracondyloid ridge, the *supracondyloid process*. From its extremity, a fibrous band, giving origin to the pronator radii teres muscle, passes to the internal supracondyloid eminence, and through the arch thus formed passes the median nerve, accompanied frequently by the brachial artery, or by a large branch rising from it. This process represents a portion of the bone completing a foramen in carnivorous animals. Much has been written on the subject. (Struthers' Edin. Med. Journ. 1848. Gruber, "Canalis supracondyloideus humeri," Mem. de l'Acad. Imp. de St. Petersburg, 1859, p. 57. Hyrtl, "Topogr. Anat." v. ii. p. 283.) The thin plate between the olecranon and coronoid fossæ is sometimes perforated.

THE RADIUS.*

The radius is the external of the two bones of the forearm, and extends from the humerus to the carpus. It is thickest at its lower extremity.

It articulates with the humerus, the ulna, the scaphoid, and the semilunar bones.

The *head*, or superior articular extremity, is of the form of a disc, with a smooth vertical margin. It presents on its summit a depression, which articulates with the capitellum of the humerus, and is surrounded by a convex part, broadest internally where it glides upon the groove internal to the capitellum. The smooth, short, cylindrical surface of the vertical margin, likewise broadest internally, rolls on the small sigmoid cavity of the ulna and within the orbicular ligament. The head is supported on a constricted portion of a cylindrical form, named the *neck*.

The *shaft* or *body* is slightly curved, with the convexity directed outwards and backwards. On its internal aspect superiorly, where it is continuous with the neck, is the *bicipital tuberosity*, to the posterior border of which is attached the tendon of the biceps muscle. Below the bicipital tuberosity the shaft presents three sides, the external of which is rounded into the others by smooth convex margins, while the anterior and posterior surfaces are separated by an acute internal margin, which gives attachment to the interosseous ligament. The *external surface* is convex transversely as well as longitudinally; it is marked near the middle by an oval rough part, about one inch and a half long, which gives insertion to the pronator radii teres. The *anterior surface* is marked in its upper part by a shallow longitudinal groove for the flexor longus pollicis; inferiorly it is expanded, and presents a flat impression corresponding with the pronator quadratus; and above the middle is the foramen for the medullary vessels, directed upwards into the bone. The *posterior surface* presents slight oblique impressions of the extensor muscles of the thumb.

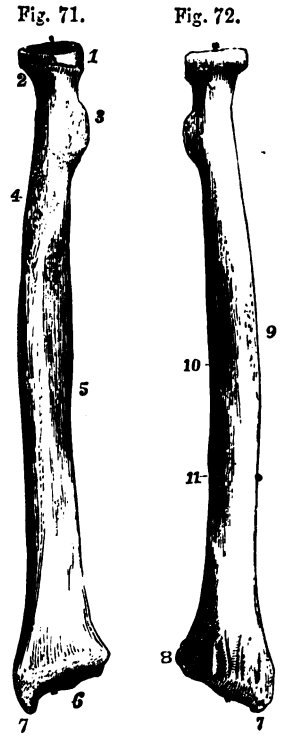
The *lower extremity* of the radius, broad and thick, and somewhat quadrilateral, presents inferiorly a large surface, which articulates with the carpus, and internally a small one, which articulates with the ulna. The carpal

* When the arm is at rest it hangs naturally with the thumb directed forwards and inwards, as in partial pronation; but in anatomical description the forearm is placed as in supination, with the thumb directed outwards and the palm of the hand looking forwards.

articular surface, which is slightly concave, is somewhat five-sided and divided by a line into a quadrilateral internal part, which articulates with the semilunar bone, and a triangular external part, which articulates with the scaphoid bone. The ulnar articular surface is vertical, and forms a right

Fig. 71.—Right Radius from before.
Fig. 72.—Right Radius from behind. ⅓

1, head, showing the hollow above for the humerus, and the short cylindrical surface surrounding it for the ulnar articulation; 2, the neck; 3, the tubercle; 4, is opposite to the oblique line; 5, internal border or interosseous ridge; the shaded part near 5 marks the slight hollow in which the flexor longus pollicis muscle lies; 6, carpal articular surface; 7, styloid process; 8, the articular hollow for the lower end of the ulna; 9, impression at the middle of the outer border of the attachment of the pronator radii teres; 10 and 11, oblique depressions marking the places of the extensor longus digitorum and extensor ossis metacarpi pollicis; between 7 and 8, the dorsal grooves for the tendons of the extensor muscles.



angle with the inferior surface; it is concave from before backwards, forming a *semilunar cavity*, in which the rounded lower end of the ulna plays. At the external angle of the inferior surface a part projecting downwards, called the *styloid process*, gives attachment to the external lateral ligament of the wrist joint, while the anterior and posterior margins are likewise rough and prominent for other ligaments. On its external and posterior aspects the inferior extremity of the radius is marked by grooves, which transmit the extensor tendons. Thus, on the external border, is a flat groove directed downwards and forwards which lodges the extensor ossis metacarpi and extensor primi internodii pollicis; and on the posterior surface are three grooves, the middle one of which, oblique and narrow, and with prominent borders, lodges the extensor secundi internodii pollicis; while of the two others, which are broad and shallower, the external, subdivided by a slight mark, gives passage to the extensores carpi radiales longior and brevior, and the internal transmits the extensor communis digitorum and extensor indicis.

THE ULNA.

The ulna is the internal of the two bones of the forearm. It is longer than the radius by the extent of the olecranon process. It is largest at its upper extremity, and is curved and three-sided elsewhere, except for a short distance at the lower end, where it is straight and cylindrical. It is inclined downwards and outwards from the humerus in such a direction that a straight line passing from the great tuberosity of the humerus downwards through the capitellum would touch the lower end of the ulna.

The ulna articulates with the humerus and the radius: in the natural skeleton it is not in contact with the carpal bones, being separated from the cuneiform bone by an inter-articular fibro-cartilage.

The *superior extremity* of the ulna presents for articulation with the humerus a large articular surface, the *great sigmoid cavity*, which looks forwards and is bounded in its posterior and upper part by the olecranon, a thick process continued upwards from the shaft, and in its lower part by the coronoid process, which projects forwards. The great sigmoid cavity is concave from above downwards, with its inferior wall deeper than its superior, and is convex from side to side, being traversed by a vertical ridge. The part external to this ridge is broad and convex above, while the part internal to the ridge is broad and concave below: a slight constriction, and sometimes a notch of division, occurs across the middle of the cavity. Continuous

Fig. 73. Fig. 74.

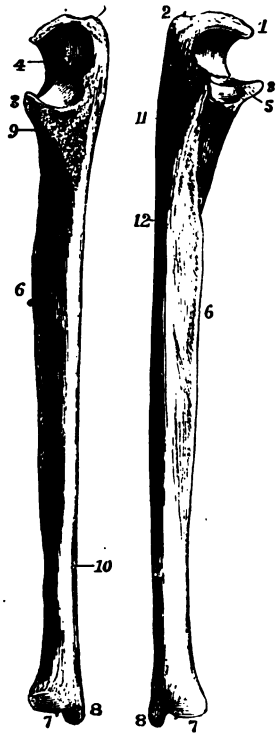


Fig. 73.—Right Ulna from before.
Fig. 74.—Right Ulna from behind and without. ½

1, point or beak of the olecranon; 2, tuberosity of the olecranon; 3, end of the coronoid process; 4, greater sigmoid articular surface, 4 points to the upper division of this surface; 5, lesser sigmoid cavity, and below it the ridge for the supinator brevis muscle; 6, external border or interosseous ridge; 7, lower extremity or head; 8, styloid process; 9, rough surface of insertion of the brachialis anticus muscle on the front of the coronoid process; below 10, the oblique line marking the attachment of the pronator quadratus muscle; 11, triangular surface for the anconeous muscle; 12, upper part of the posterior border, to the right of which the depressions for the long extensor muscles of the fingers occupy the posterior surface.

with the great is the *small sigmoid cavity*, a small articular surface on the outer side of the base of the coronoid process, slightly concave from before backwards, and articulating with the cylindrical part of the head of the radius. The *olecranon* forms by its anterior surface a part of the articular surface of the great sigmoid cavity; superiorly, broad and uneven, it gives attachment to the triceps extensor muscle, and posteriorly it presents a subcutaneous surface which is continuous with the posterior margin of the shaft. Between its anterior and superior surfaces is an acute projection which fits, in extension of the elbow, into the olecranon fossa of the humerus, and between the superior and posterior surface is a rectangular prominence which forms the point of the elbow. The *coronoid process* terminates in a sharp ridge, the prominent anterior extremity of which is received during flexion into the coronoid fossa of the humerus: its superior surface forms part of the surface of the great sigmoid cavity; the inferior surface rises gradually from the anterior surface of the bone, and is covered by a large triangular roughness which gives insertion to the brachialis anticus muscle.

The *body* or *shaft* in the upper three-fourths of its extent is three-sided, and presents a slight curve with the convexity backwards, but near the lower extremity is slender, straight and cylindrical. The *anterior surface* is grooved in the upper half, where the flexor profundus muscle takes origin; and at its lower end has an oblique line to which the pronator quadratus

is attached. Placed near the upper third is a foramen for vessels, directed upwards into the medullary cavity. The *internal surface* is smooth, and somewhat excavated superiorly on the side of the olecranon, where it gives attachment to the flexor profundus muscle, while inferiorly it is subcutaneous. The *posterior surface*, more uneven, looks outwards and backwards; an oblique ridge, descending from behind the small sigmoid cavity, limits a superior triangular area, which extends over the outer side of the olecranon and gives attachment to the anconeus muscle; immediately below the small sigmoid cavity is a short space looking directly outwards, to which the supinator brevis is attached; while the remaining and largest part of this surface is slightly impressed by the extensor muscles. Of the three *margins*, the anterior and posterior are rounded, and for the most part smooth; the external is sharp, and gives attachment to the interosseous ligament.

The *inferior extremity* presents a rounded articular head; and on the internal aspect of the head a short cylindrical projection, the *styloid process*, which descends in a line with the inner and posterior surface of the shaft, and gives attachment to the internal lateral ligament of the wrist joint. The *head* presents two aspects, of which one, flattened and circular in form, looks towards the wrist joint; whilst the other, narrow and cylindrical, looks outwards, and is received into the semilunar cavity in the contiguous border of the radius. The head and the styloid process are separated posteriorly by a groove, which is traversed by the tendon of the extensor carpi ulnaris; and inferiorly by a depression, into which the triangular fibro-cartilage which intervenes between the ulna and the carpus is inserted.

THE CARPUS.

The carpus is composed of eight short bones, which are disposed in two ranges, four in each range. Enumerated from the radial to the ulnar side, the bones which constitute the first or superior range are named scaphoid, semilunar, cuneiform, and pisiform; those of the second or inferior range, trapezium, trapezoid, os magnum, and unciform.

Fig. 75.

Fig. 75. — Half-diagrammatic View of the Carpus and Proximal Parts of the Metacarpal Bones, from before, with the Carpal Bones slightly separated to show the form of their surfaces of contact with each other. ⅔

1, scaphoid bone; 2, semilunar, presenting in this instance, as often occurs, a small surface of articulation with the unciform bone; 3, cuneiform or pyramidal; 4, pisiform, laid upon the last; 5, trapezium, the figure is placed upon the ridge, to the inside of which is the groove for the tendon of flexor carpi radialis; 6, trapezoid bone; 7, os magnum, the figure is placed on the tuberosity; 8, unciform bone, the figure is placed on the unciform process. The metacarpal bones will be distinguished by the first being articulated separately with the trapezium. The articulation of the os magnum with the fourth metacarpal bone is represented somewhat too large.

The dorsal surface of the carpus is convex, the palmar is concave from side to side, the concavity being bounded by four prominences, one at the outer and one at the inner extremity of each range. The anterior annular

ligament is stretched across the carpus between these prominences, so as to form a canal for the transmission of the flexor tendons.

The superior surfaces of the scaphoid, semilunar and cuneiform bones form, when in apposition, a continuous convexity which corresponds with the concavity presented by the radius and the interarticular cartilage, while the pisiform bone is attached in front of the cuneiform, with which alone it articulates. The line of articulation between the superior and inferior ranges is concavo-convex from side to side, the trapezium, trapezoid and os magnum bounding a cavity which lodges the external part of the scaphoid, and the os magnum and unciform rising up in a convexity, which is received into a hollow formed by the scaphoid, semilunar, and cuneiform bones.

THE SCAPHOID BONE.

The scaphoid, or *navicular* bone, the largest and most external of the first row of carpal bones, is of a curved form, and lies with its longest axis directed outwards and downwards. Its superior surface, convex and smooth for articulation with the radius, is inclined backwards, so that the posterior surface of the bone is not so deep as the anterior. The internal surface, narrow from above downwards, articulates with the semilunar bone. The outer extremity, rough superiorly for the attachment of ligaments, presents inferiorly an articular convexity, which occupies the hollow formed by the upper surfaces of the trapezium and trapezoid bones, and is continuous with a large concave surface extending over the rest of the inferior aspect of the bone, and articulating with the os magnum. The fore part of the outer extremity of the scaphoid bone projects forwards, forming one of the tubercles to which the anterior annular ligament is attached. The scaphoid articulates with five bones, viz., the radius, the semilunar, trapezium, trapezoid, and os magnum.

THE SEMILUNAR BONE.

The semilunar, or *lunate* bone, irregularly cubic, is named from the crescentic concavity from before backwards of its inferior surface, which rests on the head of the os magnum, and frequently also by a bevelled edge slightly on the unciform bone. Its external surface is vertical, and articulates with the scaphoid bone; its internal surface looks downwards and inwards, is much deeper and narrower than the external, and articulates with the cuneiform. The convex superior surface, which articulates with the radius, is inclined, like that of the scaphoid, more backwards than forwards, and hence the anterior surface is deeper than the posterior. The semilunar articulates with five bones, viz., the radius, scaphoid, cuneiform, os magnum, and unciform.

THE CUNEIFORM BONE.

The cuneiform or *pyramidal* bone, is somewhat wedge-shaped, its internal extremity, rough for ligaments, forming the blunt narrow end of the wedge. Superiorly it presents an articular surface, which glides upon the triangular cartilage interposed between it and the ulna; externally it articulates with the semilunar bone, and inferiorly with the unciform, by means of a surface which is concavo-convex from without inwards. Its anterior surface is distinguished from the posterior by a smooth circular facet on its outer half, which articulates with the pisiform bone. The cuneiform articulates with three bones, viz., the semilunar, pisiform, and unciform.

THE PISIFORM BONE.

The pisiform bone, or *os rotundum*, so called from its resemblance to a pea, lies on a plane anterior to the other bones of the carpus. Posteriorly it possesses an articular surface, which rests on the cuneiform bone. The mass of the bone is so inclined from this surface downwards and outwards, that the pisiform bone of one hand is distinguishable from that of the other.

Fig. 76.—Dorsal View of the Carpus, with a portion of each of the Metacarpal Bones. ½

1, scaphoid; 2, semilunar; 3, cuneiform; 4, pisiform; 5, trapezium; 7, trapezoid; 8, os magnum; 9, unciform.

Fig. 76.

THE TRAPEZIUM.

The trapezium, or *os multangulum majus*, is the most external of the second row of carpal bones. It presents a rhombic form when seen from its dorsal or palmar aspect, and has its most prominent angle directed downwards. Its anterior surface is marked by a vertical groove traversed by the tendon of the flexor carpi radialis muscle, and external to the groove by a ridge, or tubercle, one of the four prominences which give attachment to the anterior annular ligament. Of the internal sides of the rhomb, the superior articulates with the scaphoid bone, the inferior with the trapezoid bone, and by a small facet close to the inferior angle also with the second metacarpal bone. Of the external sides the superior is rough, and the inferior presents a smooth surface convex from behind forwards, and concave from without inwards, which articulates with the metacarpal bone of the thumb, and is separated by a rough line at the inferior angle from the surface for the second metacarpal bone. The trapezium articulates with four bones, viz., the scaphoid, trapezoid, and first and second metacarpals.

THE TRAPEZOID BONE.

The trapezoid bone, or *os multangulum minus*, is considerably smaller than the trapezium. Its longest diameter is from before backwards. Its posterior surface, which is pentagonal, is much larger than the anterior. The external inferior angle of the anterior surface is distinguished by being prolonged a little backwards between the trapezium and second metacarpal bone. The superior surface articulates with the scaphoid bone; the external with the trapezium; the internal with the os magnum; and the inferior by a large surface convex from side to side with the second metacarpal bone. The trapezoid articulates with four bones, viz., the scaphoid, trapezium, os magnum, and second metacarpal bone.

THE OS MAGNUM.

The os magnum, or *os capitatum*, is the largest of the carpal bones. In form it is elongated vertically, rectangular inferiorly, rounded superiorly. The articular surface of the superior extremity or *head* is prolonged on the outer, but not on the inner side, and is continued further down behind than in front. A *neck* is formed beneath by depressions on the anterior and posterior surfaces. The anterior surface of the bone is much narrower than the posterior. The posterior surface projects downwards at its

internal inferior angle. On the external side beneath the surface for the scaphoid is a short surface for the trapezoid bone; and on the internal surface is a vertically elongated surface which articulates with the unciform bone. Inferiorly this bone articulates by three distinct surfaces, of which the middle is much the largest, with the second, third, and fourth metacarpal bones. The os magnum articulates with seven bones, viz., the scaphoid, semilunar, trapezoid, unciform, and second, third, and fourth metacarpal bones.

THE UNCIFORM BONE.

The unciform bone is readily distinguished by the large process projecting forwards and curved slightly outwards on its anterior surface. Seen from the front or behind, it has a triangular form. Its external surface is vertical, and articulates with the os magnum; its inferior surface is divided nto two facets which articulate with the fourth and fifth metacarpal bones; its superior surface, meeting the cuneiform, is concavo-convex, inclines upwards and outwards towards the head of the os magnum, and is separated internally by a rough border from the inferior surface. The unciform articulates with five bones, viz., the os magnum, semilunar, cuneiform, and fourth and fifth metacarpal bones.

THE METACARPUS.

The metacarpus, the part of the hand which supports the fingers, consists of five shafted bones, which are numbered from without inwards. These bones are placed in a slightly arched plane, and are nearly parallel one with the other, with the exception of the first, which diverges from the second.

Fig. 77.

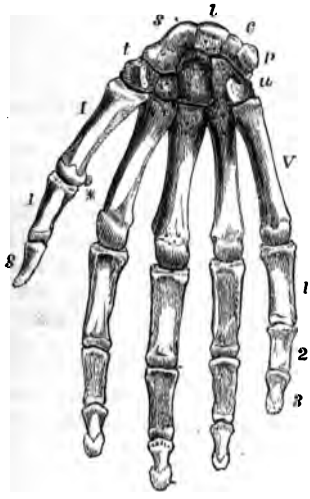


Fig. 77.—The Right Hand from before. ½

s, scaphoid bone; *l*, semilunar; *c*, cuneiform; *p*, pisiform; *t*, trapezium; next it the trapezoid, not lettered; next the os magnum, also not lettered; *u*, unciform.

I to V, the metacarpal bones; 1, 3, first and second phalanges of the thumb; 1, 2, 3, the first, second, and third phalanges of the little finger, and similarly for the other three fingers, not marked; *, one of the sesamoid bones of the thumb seen sidewise.

The metacarpal bones are slightly curved, so as to present a concavity directed forwards. They are terminated at their carpal extremities by expanded portions of different forms, and at the digital ends by large rounded heads. The first metacarpal bone is thicker and shorter than the others. The remaining four decrease regularly in length, according to their position from without inwards, and the second and third are thicker than the fourth and fifth.

The *shaft* of the first metacarpal bone is somewhat compressed from before backwards, flat behind, and transversely convex in front. The shafts of the others are prismatic, presenting a broad surface towards the back of the hand, and towards the palm a rounded margin between the two lateral surfaces. They are most slender immediately beyond the carpal extremity, and become gradually thicker towards the head. They present on their dorsal surfaces each a triangular subcutaneous area, bounded

by lines which, proceeding from the sides of the head, pass upwards and converge in the second, third, and fourth metacarpal bones opposite the middle of the carpal extremity, and in the fifth towards its inner side.

The *heads* or *digital extremities* articulate with the proximal phalanges. Their smooth rounded surfaces are broader, and extend further on the palmar than on the dorsal aspect of the bones; and on the sides present hollows and elevations for the attachment of ligaments.

The *carpal extremity* presents distinctive peculiarities in each metacarpal bone. That of the first has only one articular surface, concave from before backwards, and convex from side to side, which articulates with the trapezium; and posteriorly a rough prominence, to which the extensor metacarpi pollicis is attached. The second presents a transversely concave surface which receives the trapezoid bone; on the radial side it articulates by a small facet on its posterior part with the trapezium, on the ulnar side with the third metacarpal bone, and by a narrow facet wedged between the third metacarpal and trapezoid bones, with the os magnum. The third bone articulates superiorly with the os magnum, and on the sides with the contiguous metacarpal bones: at its posterior and outer angle it forms a projection upwards. The fourth articulates principally with the unciform bone above, but also by a narrow facet with the os magnum; on its radial side are two small surfaces, and on the ulnar side one, for articulation with the adjacent metacarpal bones. The fifth articulates superiorly with the unciform bone by means of a concave surface inclined slightly outwards, and externally with the fourth metacarpal bone, while on its ulnar side it presents a rough and prominent tuberosity.

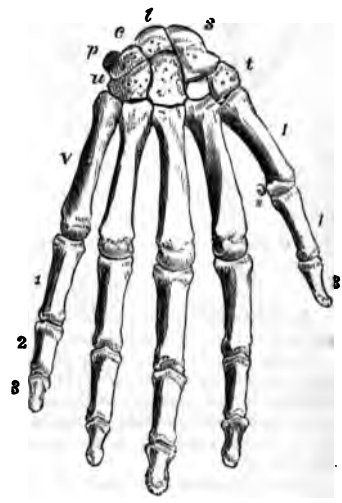
From the proximal position of its epiphysis, the metacarpal bone of the thumb has been considered by Winslow and some other anatomists, as a phalanx of the first row, and the bone which it supports a phalanx of the middle row.

THE DIGITAL PHALANGES.

Fig. 78.—Right Hand seen from behind. ½

The indications are the same as in the preceding figure.

Fig. 78.



The digital phalanges, or *internodia*, are fourteen in number; three for each finger, except the thumb, which has only two. In each instance the first or proximal phalanx is longer than the second, and the second longer than the third.

Those of the *first row* are slightly curved like the metacarpal bones. Their dorsal surfaces are smooth and transversely convex; the palmar are flat from side to side, and bounded by rough margins, which give insertion to the fibrous sheaths of the flexor tendons. Their proximal extremities are thick, and articulate each by a transversely oval concave surface with the corresponding metacarpal bone. Their distal extremities, smaller and more

compressed antero-posteriorly, are each divided by a shallow groove into two condyles.

Those of the *middle row* are four in number. Smaller than those of the preceding set, they resemble them in form, with this difference, that their proximal extremities present on the articular surface a slight middle elevation and two lateral depressions, adapted to articulate with the condyles of the first phalanges.

The *terminal* or *ungual* phalanges, five in number, have proximal extremities similar to those of the middle row, but with a rough depression in front, where the flexor tendons are inserted. They taper towards their somewhat flattened and expanded free extremities, which are rough and raised round the margins and upon the palmar aspect in the ungual process.

SESAMOID BONES.—A pair of sesamoid bones is placed in the palmar wall of the metacarpo-phalangeal articulation of the thumb; and similar nodules, single or double, are sometimes found in the corresponding joint of one or more of the other fingers, most frequently of the index and little fingers.

DEVELOPMENT OF THE UPPER LIMB.

FIRST APPEARANCE OF THE LIMBS.—The earliest traces of limbs in the human embryo are observed in the fourth or fifth week as elevations of the ventral plates on the sides of the body, tipped with a thickening of the cuticle. In the fifth or sixth week there is distinguishable in each a laterally compressed expansion, the rudimentary hand or foot, and a more cylindrical pedicle, the arm or leg. About the eighth week the division into fingers and toes takes place, the pollex of each

Fig. 79.

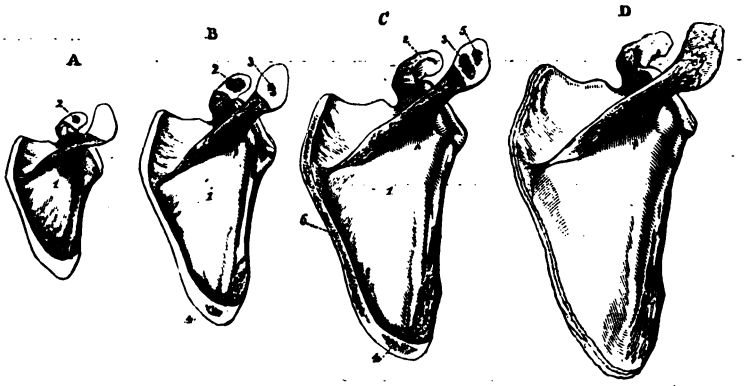


Fig. 79.—OSSIFICATION OF THE SCAPULA.

A, the scapula from a child of about one year old. 1, shows the large spreading ossification from the primary centre. 2, the commencing nucleus in the coracoid process.

B, the scapula from a boy of about fifteen or sixteen years. The coracoid process, (represented as too much separate in the figure), is now partially united at its base; a nucleus, 3, has appeared in the acromion, and another, 4, at the lower angle.

C, shows the condition of the scapula at seventeen or eighteen years of age; a second point, 5, has appeared in the acromion, and ossification has advanced into the ridge of the base, 6.

D, the scapula of a man of about twenty-two years of age; the acromion and the ridge of the base are still separate. A thin scale on the coracoid process and an epiphysis of the glenoid head, which sometimes occur, have been omitted.

limb being developed on the superior margin. The upper limb appears before the lower, and sooner exhibits a separation of digits. The division into arm and forearm, thigh and leg, is observable about the eighth week (Kölliker, loc. cit.). The nerves are seen extending directly into the limbs soon after their first appearance; but it is not determined whether the bones and muscles are derived from extensions of the dorsal plates, or have an independent origin in the ventral plates.

Ossification of the upper limb.—With the exception of the clavicle, all the bones of the upper limb begin to ossify from cartilage. The *Scapula* is developed in the greater part of its extent from a single osseous nucleus, but possesses also supplementary nuclei in the coracoid process and acromion, and along the base. The nucleus of the coracoid process is especially worthy of attention, both because it appears in the first year, while the other supplementary nuclei are formed only after puberty, and because, although reduced to a mere epiphysis in mammals, it forms a distinct and sometimes large bone in other vertebrate animals. The acromion is ossified from two or more nuclei. Along the base of the young scapula a strip of cartilage extends, corresponding with a much more largely developed permanent cartilage found in many animals; and in this there first appears a nucleus of bone at the inferior angle, then a prolonged ossification throughout its length. Occasionally a separate epiphysial lamina occurs, in the border of the glenoid cavity.

Fig. 80.—Ossification of the Clavicle.

a, the clavicle of a fœtus at birth, osseous in the shaft, 1, and cartilaginous at both ends.

b, clavicle of a man of about twenty-three years of age; the shaft, 1, fully ossified to the acromial end; the sternal epiphysis, 2, is represented rather thicker than natural.

Fig. 80.

The *Clavicle* begins to ossify before any other bone in the body. Its ossification commences before the deposition of cartilage in connection with it, but afterwards progresses in cartilage as well as in fibrous substance. It is formed from one principal piece, and has a thin epiphysis at its sternal end.

Fig. 81.

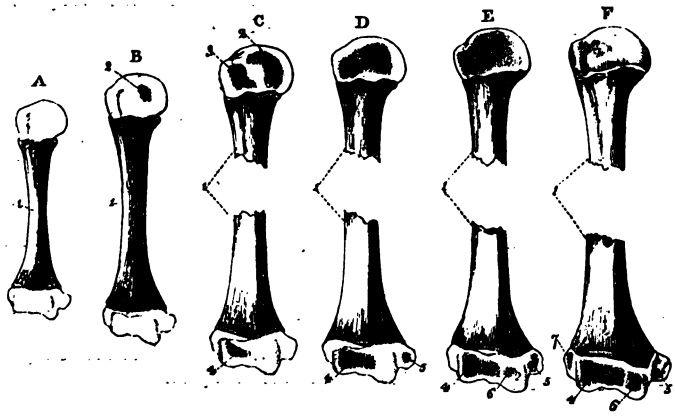


Fig. 81.—Ossification of the Humerus.

A, humerus of a full-grown fœtus; B, humerus at two years of age; C, in the third year; D, at the beginning of the fifth year; E, at about the twelfth year; F, at the age of puberty.

1, the primary piece for the shaft; 2, nucleus for the articular head; 3, that for the tuberosity; 4, for the radial condyle and adjacent part of the trochlea; 5, for the inner or trochlear eminence; 6, for the inner part of the trochlea; 7, for the external or capitellar eminence.

The *Humerus* is formed, like most of the long bones, from a principal centre for the shaft, and from a superior and an inferior terminal epiphysis. The superior epiphysis is formed by the union of two original nuclei—one in the head, the other in the great tuberosity, to which is added, according to Béclard and Humphry, a nucleus belonging to the small tuberosity. The inferior epiphysis has four original nuclei, the largest of which extends inwards from the capitellum, while a small one appears at the inner part of the trochlea, and one in each supracondyloid eminence; the internal supracondyloid epiphysis remains distinct from the other three nuclei, which become fused into one mass previous to their union with the shaft.

The *Radius and Ulna* are each developed from an osseous centre in the middle of the shaft and from an epiphysial nucleus in each extremity. The epiphyses of the ulna are very small; the upper one involves only the extremity of the olecranon.

The *Carpus* is entirely cartilaginous at birth. Each *Carpal bone* is ossified from a single nucleus.

The *Metacarpal bones* and *Phalanges* are formed each from a principal piece and one epiphysis. The ossification of the principal pieces begins at an early period. In the four inner metacarpal bones the epiphysis is at the distal extremity, while in the metacarpal bone of the thumb and in the phalanges it is placed at the proximal extremity.

PERIODS OF OSSIFICATION OF THE BONES OF THE UPPER LIMB.

I. *Scapula.*
- The principal nucleus appears in the 7th or 8th week.
- The nucleus of the coracoid process appears in the 1st or 2nd year.
- The two nuclei of the acromion appear from the 14th to the 16th year.
- The nuclei of the inferior angle, base, and glenoid cavity, appear from the 16th to the 18th year.
- The coracoid process and body unite about the time of puberty.
- The other parts unite from the 22nd to the 25th year.

II. *Clavicle.*
- The principal nucleus (earliest of all bones) appears about the 6th week.
- The epiphysis of the sternal end appears from the 18th to the 20th year.
- The epiphysis and shaft unite about the 25th year.

III. *Humerus.*
- The nucleus of the shaft appears in the 7th week.
- The nucleus of the head appears in the 2nd year.
- The nucleus of the great tuberosity appears in the 3rd year.
- The nucleus of the small tuberosity (when separate) appears in the 5th year.
- The nucleus of the capitellum appears in the 3rd year.
- The nucleus of the internal supracondyloid eminence appears in the 5th year.
- The nucleus of the trochlea appears in the 11th or 12th year.
- The nucleus of the external supracondyloid eminence appears in the 13th or 14th year.
- The nucleus of the tuberosity and head unite in the 5th year.
- The capitellar, trochlear, and external supracondyloid nuclei unite with the shaft in the 16th or 17th year.
- The internal supracondyloid nucleus unites with the shaft in the 18th year.
- The superior epiphysis and shaft unite in the 20th year.

IV. *Radius.*
- The nucleus of the shaft appears in the 7th or 8th week.
- The nucleus of the carpal extremity appears at the end of the 2nd year.
- The nucleus of the head appears in the 5th year.
- The superior epiphysis and shaft unite about the 17th or 18th year.
- The inferior epiphysis and shaft unite about the 20th year.

V. *Ulna.*
- The nucleus of the shaft appears in the 8th week.

Fig. 82.

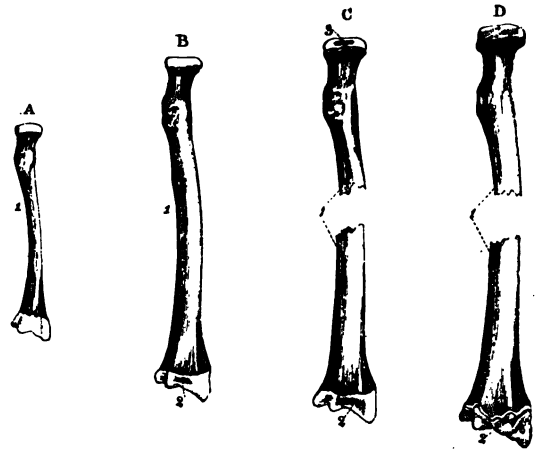


Fig. 82.—Ossification of the Radius.

A, the radius of a full-grown fœtus; B, the radius at about two years of age; C, at five years; D, at about eighteen years.

1, the primary piece or shaft; 2, the ossific point of the lower or carpal epiphysis; 3, that of the upper end. In D, the upper epiphysis is already united to the shaft, while the lower epiphysis is still separate.

Fig. 83.

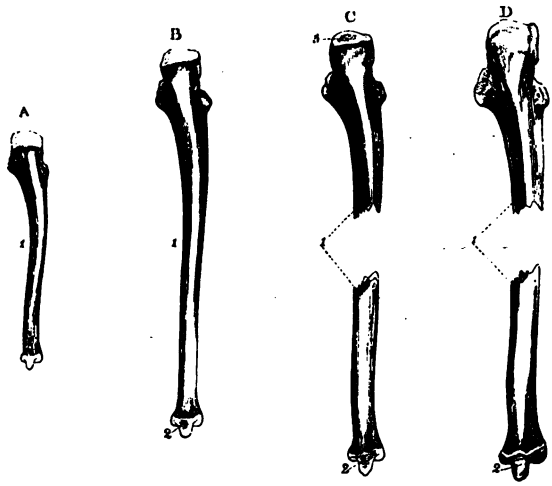


Fig. 83.—Ossification of the Ulna.

A, the ulna of a child at birth; B, the ulna of a child at the end of the fourth year; C, of a boy of about twelve years of age; D, the ulna of a male of about nineteen or twenty years.

1, the primary piece of the shaft; 2, the nucleus of the lower epiphysis; 3, the nucleus of the upper epiphysis. In D, the upper epiphysis is united to the shaft, while the lower one is still separate.

Fig. 84.

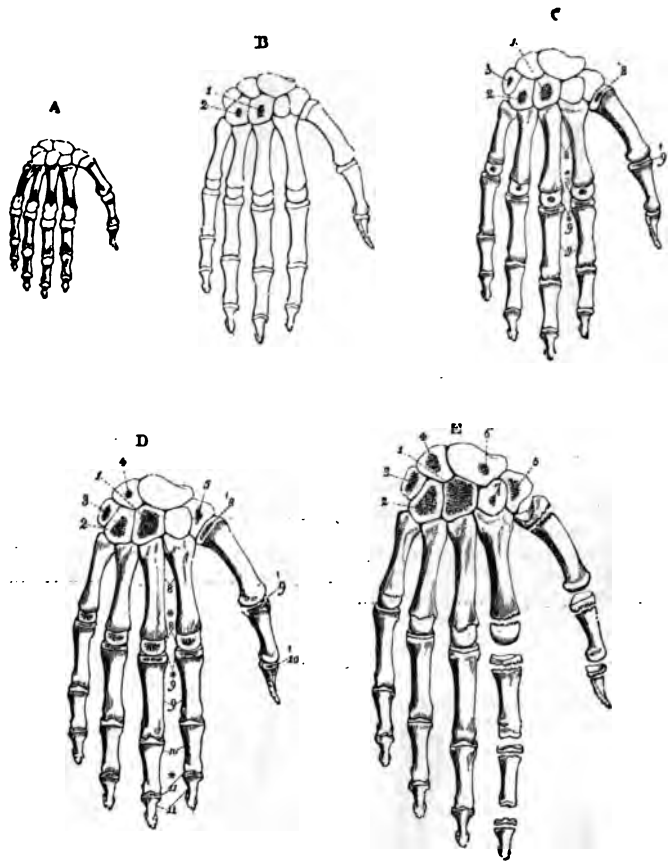


Fig. 84.—Ossification of the Bones of the Hand.

A, represents the state of the bones and cartilages at the period of birth. The carpus is entirely cartilaginous. Each of the metacarpal bones and digital phalanges has its primary centre of ossification.

B, the state of the bones in a child at the end of the first year; the os magnum and unciform bone have begun to ossify.

C, the condition about the third year. Additional centres of ossification are seen in the cuneiform and in the proximal epiphysis of the first and the distal epiphyses of the other four metacarpal bones, and in the proximal epiphyses of the first row of phalanges.

D, the condition at the fifth year. Additional centres have been formed, first in the trapezium, and later in the semilunar bone, and in the middle and distal phalanges: (the figure does not show them distinctly in the middle phalanges).

E, the condition at about the ninth year. Additional centres have been formed in the scaphoid and trapezoid bones, and the more developed epiphyses of the metacarpal bones and phalanges are shown, in the first and second separately.

1, os magnum; 2, unciform; 3, cuneiform; 4, semilunar; 5, trapezium; 6, scaphoid; 7, trapezoid; 8, metacarpal bones, the principal piece; 8*, four metacarpal epiphyses; 8′, that of the thumb; 9, the first range of phalanges; 9*, their epiphyses; 9′, that of the thumb; 10, second range of phalanges; 10′, epiphysis of terminal phalanx of thumb; 11, terminal range of phalanges of the fingers; 11*, their epiphyses.

Ulna—continued.

The epiphysis of the carpal extremity appears in the 4th or 5th year.
The epiphysis of the olecranon appears in the 10th year.
The superior epiphysis and shaft unite about the 17th year.
The inferior epiphysis and shaft unite about the 20th year.

VI. *Carpus.*

The nucleus of the os magnum appears in the 1st year.
The nucleus of the unciform bone appears in the 1st or 2nd year.
The nucleus of the cuneiform bone appears in the 3rd year.
The nuclei of the trapezium and semilunar bones appear in the 5th year.
The nucleus of the scaphoid bone appears in the 8th year.
The nucleus of the trapezoid bone appears in the 8th or 9th year.
The nucleus of the pisiform bone appears in the 12th year.

VII. *Metacarpus.*

The nuclei of the shafts appear in the 8th and 9th week.
The nuclei of the epiphyses appear from the 3rd to the 5th year.
The epiphyses and shafts unite about the 20th year.

VIII. *Phalanges.*

The nuclei of the shafts appear in the 8th, 9th, and 10th weeks.
The nuclei of the epiphyses appear from the 3rd or 4th to the 5th or 6th years.
The epiphyses and shafts unite before the 20th year.

NOTE. From what is stated above it appears that in the bones of the arm and forearm the epiphyses which meet at the elbow-joint begin to ossify later and unite with their shafts earlier than those at the opposite ends of the bones, while in the bones of the thigh and leg the epiphyses distant from the knee-joint are the latest to ossify (excepting the fibula) and the first to unite with their shafts. In the bones of the arm and forearm the nutrient foramina are directed towards the elbow; in those of the thigh and leg they are directed away from the knee. Thus in each bone the epiphysis of the extremity towards which the nutrient foramen is directed is the first to be united to the shaft.

V.—THE PELVIS AND LOWER LIMB.

The divisions of the lower limb are the haunch or hip, thigh, leg, and foot. In the haunch is the innominate bone, which, as entering into the formation of the pelvis, likewise constitutes part of the skeleton of the trunk; in the thigh is the femur; in the leg the tibia and fibula; and at the knee a large sesamoid bone, the patella. The foot is composed of three parts; the tarsus, metatarsus, and phalanges.

THE INNOMINATE BONE.

The innominate bone, *os coxæ*, or *pelvic bone*, with its neighbour of the opposite side and the addition of the sacrum and coccyx, forms the pelvis; it transmits the weight of the body to the lower limb. In form it is constricted in the middle and expanded above and below, and is so curved upon itself that while the superior expansion is directed inwards posteriorly and outwards anteriorly, the inferior part is curved inwards so as to reach the middle line in front. On the external aspect of the constricted portion is the *acetabulum*, a cavity which articulates with the femur, and perforating the inferior expansion is a large opening, the *obturator foramen*. The superior wider part of the bone forms part of the abdominal wall: the inferior enters into the formation of the true pelvis. The innominate bone articulates with its fellow of the opposite side, with the sacrum and with the femur.

In the description of this bone it is convenient to recognise as distinct the three parts of it which are separate in early life, viz., the *ilium*, *os pubis*, and *ischium*. These three portions meet at the acetabulum, in the

formation of which they all take part; and the os pubis and ischium also meet on the inner side of the obturator foramen.

Fig. 85.

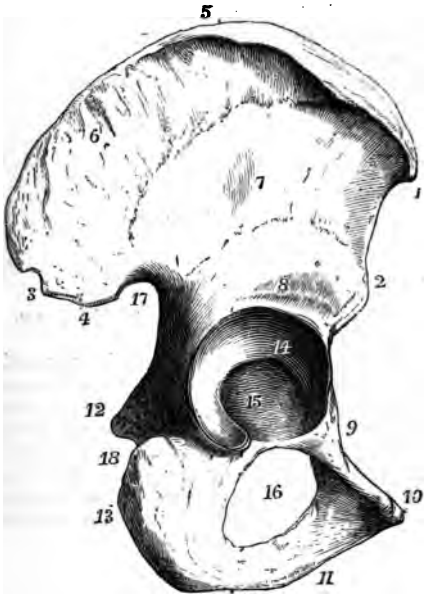


Fig. 85.—Right Os Innominatum from the dorsal aspect. ⅛

1, anterior superior spinous process; 2, anterior inferior ditto; 3, posterior superior; 4, posterior inferior spinous process; 5, crest of the ilium; 6, surface occupied by the gluteus medius muscle above the superior curved line above 3, is a rough surface to which the gluteus maximus is attached; 7, surface between the superior and inferior curved lines occupied by the gluteus minimus; 8, groove above the acetabulum, occupied by the posterior tendon of the rectus femoris; 9, superior ramus of the pubis and pectineal eminence; 10, crest and spinous process of the pubis; 11, place of meeting of the descending or inferior ramus of the pubis with the ascending ramus of the ischium; 13, tuberosity of the ischium; 14, cartilaginous surface of the acetabulum; and 15, synovial depression and pit for the round ligament; 16, thyroid, or obturator foramen; 17, greater, and 18, lesser sciatic notches; between the acetabulum and the ischial tuberosity is seen the groove occupied by the obturator externus muscle.

The *ilium* constitutes the superior expanded portion of the bone, and forms a part of the wall of the acetabulum by its inferior extremity. Above the acetabulum it is limited anteriorly and posteriorly by margins which diverge at right angles one from the other, and superiorly by an arched thick and extensive border, the *crista ilii*. The *crest* is curved like the letter *f*, the anterior extremity pointing slightly inwards and the posterior outwards; its surface is broadest in its anterior and posterior thirds, it is rough for the attachment of muscles, and on it may be distinguished an external and internal lip and an intermediate space. The anterior extremity of the crest forms a projection forwards called the *anterior superior spine of the ilium*, and, separated from it by a concave border, and placed immediately above the acetabulum, is another eminence called the *anterior inferior spine*: the projecting posterior extremity of the crest forms the *posterior superior spine*, and separated from it by a notch is the *posterior inferior spine*, below which the posterior border of the bone is hollowed out into the *great sciatic notch*. The external surface, or *dorsum* of the ilium, concavo-convex from behind forwards, presents, close to the posterior extremity of the crest, a roughness of some extent, to which the gluteus maximus muscle is attached, and is traversed by two rough arched lines, one of which, *the superior curved line*, beginning in front at the upper border of the bone, about an inch and a half from its anterior extremity, arches backwards to the upper part of the great sciatic notch, while the other, *the inferior curved line*, shorter

and less strongly marked, extends from the space between the anterior spinous processes to the middle of the great sciatic notch. The space between the crest and the superior curved line has the form of a curved triangle, broad behind and pointed in front, and gives attachment to the gluteus medius muscle, while that between the two curved lines gives attachment to the gluteus minimus. The internal surface of the ilium is divided into three parts. The anterior of these, the largest, is called the *iliac fossa;* it is concave and smooth, and towards the middle of it the bone is very thin. The posterior part is subdivided; presenting inferiorly for cartilaginous articulation with the sacrum the smooth but uneven *auricular surface*, broad in front and extending to the posterior inferior spine behind; and superiorly a more uneven and rough surface for the attachment of ligaments. The third part, entering into the formation of the true pelvis, is not distinguished by any mark in the adult from the ischium and os pubis; it is separated from the iliac fossa by a smooth border, the iliac portion of the *ilio-pectineal line*, which extends from the auricular surface to the pubic spine.

Fig. 86.

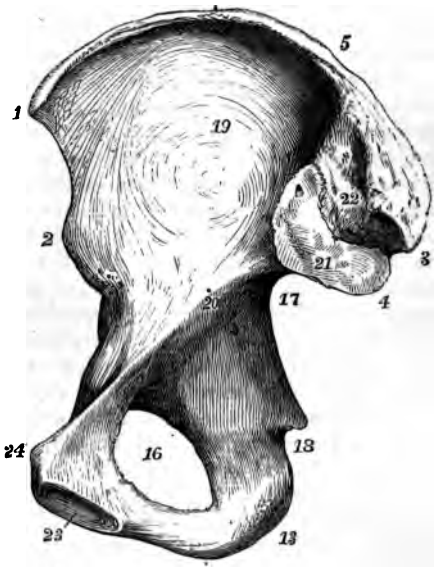


Fig. 86.—Right Os Innominatum, from the inner or pelvic surface. $\frac{1}{8}$

2, 3, 4, 5, 13, 16, 17, and 18, indicate the same parts as in the preceding figure; 19, iliac fossa; 20, ilio-pectineal line or brim of the true pelvis, ending at 24; 21, auricular cartilaginous sacro-iliac surface; 22, rough tuberculated surface for the posterior sacro-iliac ligaments; 23, oval surface of the symphysis pubis; 24, spinous process of the pubis, terminating the crest of the pubis and the ilio-pectineal line; between 17 and 20, the pelvic surface of the ilium.

The *os pubis* or *os pectinis* forms the anterior wall of the pelvis, and bounds the obturator foramen in the upper half of its extent. At its outer and upper extremity it forms a part of the acetabulum; at its inner extremity it presents an elongated oval surface, articulating by fibro-cartilage with the bone of the opposite side, its junction with which is called the *symphysis pubis*. The part which passes downwards and outwards below the symphysis is called the *inferior* or *descending ramus*, the upper part is called the *superior* (or *horizontal*) *ramus*, and the flat portion between the rami may be distinguished as the *body*. The deep or pelvic surface of the os pubis is smooth; the outer surface is roughened near the symphysis by the attachments of muscles. At the superior extremity of the symphysis is the *angle* of the pubis, and extending outwards from this on the superior border is the rough *crest*, terminating in the projecting *spine*. The descending ramus is flat from before backwards; the superior or ascending ramus becomes prismatic, and increases in thickness as it passes upwards and out-

wards, and between its posterior and superior surfaces there is prolonged outwards from the spine a ridge called the *pectineal line*, which is the pubic portion of the *ilio-pectineal line*. The surface in front of the pectineal line is covered by the pectineus muscle; the inferior surface of the superior ramus presents a deep groove for the obturator vessels and nerve, directed from behind forwards and inwards. Above the acetabulum the concavity of the border extending from the anterior inferior spine of the ilium to the spine of the pubis is interrupted by a slight elevation, the *ilio-pectineal eminence*, situated at the junction of the os pubis and ilium.

The *ischium* is the posterior and lowest part of the os innominatum, and bounds the obturator foramen in the lower half of its extent. Superiorly it forms about two-fifths of the acetabulum, inferiorly it is enlarged in a thick projection, the *tuberosity*, and this part, diminishing in size, is continued forwards into the *ramus*. On its posterior border, behind the acetabulum, a sharp process, the *spine*, projecting with an inclination inwards, forms the inferior limit of the *great sciatic notch*, and is separated from the tuberosity by a short interval, the *small sciatic notch*, against the smooth margin of which glides the tendon of the obturator internus muscle. In front of this, on the external surface, a horizontal groove, occupied by the tendon of the obturator externus muscle, lies between the inferior margin of the acetabulum and the tuberosity. The tuberosity, which is the part on which the body rests in the sitting posture, presents a rough surface continuous with the internal margin of the ramus, and on which may be distinguished four impressions, viz., on its upper and broad part two slight hollows, which are placed side by side, the external corresponding to the attachment of the semimembranosus muscle, and the internal to the conjoined origin of the biceps and semitendinosus; and inferiorly two elongated rough elevations, likewise side by side, the external giving attachment to the adductor magnus muscle, and the internal to the great sacro-sciatic ligament: there is likewise along the outer margin a rough elevated line, marking the place of origin of the quadratus femoris muscle. The ramus of the ischium is flattened like the descending ramus of the pubis, with which it is continuous on the inner side of the obturator foramen.

The *acetabulum* is a *cotyloid* or cup-shaped cavity, looking outwards, downwards and forwards, and surrounded in the greater part of its circumference by an elevated margin, which is most prominent at the posterior and upper part; while at the opposite side, close to the obturator foramen, it is deficient, leaving the *notch* or *incisura*. Its lateral and upper parts present a broad bent riband-like smooth surface, which articulates with the head of the femur, and in the recent state is coated with cartilage, but the lower part of the cup and the region of the notch are depressed below the level of the articular surface, lodge a mass of fat, and have no cartilaginous coating. Rather more than two-fifths of the acetabulum are formed from the ischium, less than two-fifths from the ilium, and the remainder from the os pubis. The iliac portion of the articular surface is the largest, the pubic the smallest: the non-articular surface belongs chiefly to the ischium.

The *obturator* or *thyroid* foramen, also called *foramen ovale*, is internal and inferior to the acetabulum. In the male it is nearly oval, with the long diameter directed downwards and outwards; in the female it is more triangular, or narrowed at its lower part. In the recent state it is closed by a fibrous membrane, except in the neighbourhood of the groove in its upper margin.

THE PELVIS.

The ossa innominata with the sacrum and coccyx form the osseous walls of the pelvis.

This part of the skeleton may be considered as divided into two parts at the level of the upper border of the symphysis pubis, the sacral promontory and the ilio-pectineal lines. The circle thus completed constitutes the *brim* or *inlet* of the lower or *true pelvis;* the space above it, between the iliac fossæ, belongs really to the abdomen, but has been called the upper or *false pelvis.* The inferior circumference, or *outlet* of the pelvis, presents three bony eminences, the coccyx and the tuberosities of the ischium. Between the tuberosities of the ischium in front is the *pubic* or *sub-pubic arch,* which bounds an angular space extending forwards to the symphysis, and is formed by the descending rami of the ossa pubis and the ascending rami of the ischia. The interval between the sacrum and coccyx and the ischium on each side is bridged over in the recent state by the sacro-sciatic ligaments, which therefore assist in bounding the outlet of the pelvis.

Fig. 87.

VIEW OF THE PELVIS OF A MIDDLE-AGED MAN, AS SEEN FROM BEFORE, IN THE ERECT ATTITUDE OF THE BODY. ¼

1, 2, anterior extremities of the crest of the ilium in front of the widest transverse diameter of the upper or false pelvis; 3, 4, acetabula; 5, 5, thyroid or obturator foramina; 6, sub-pubic angle or arch.

Fig. 87.

Fig. 88.

VIEW OF THE PELVIS OF A MIDDLE-AGED WOMAN. ¼

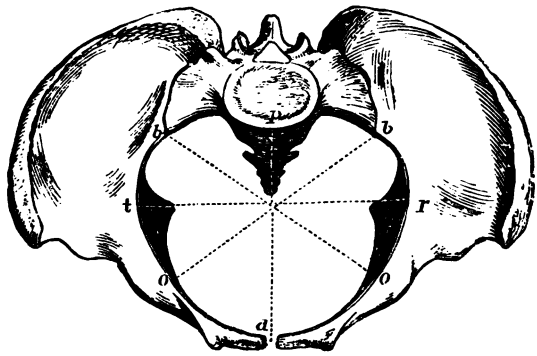
Similarly placed with that shown in the preceding figure, and designed to illustrate, by comparison with it, the principal differences between the male and female pelvis, *viz.*, the greater distance in the female between the acetabula, the wider and shallower true pelvis, the triangular form of the obturator foramen, the greater width between the tuberosities of the ischium, and the greater width of the sub-pubic arch. The numbers indicate the same parts as in the preceding figure.

Fig. 88.

Position of the Pelvis.—In the erect attitude of the body, the pelvis is so inclined that the plane of the brim of the true pelvis forms an angle with the horizontal, varying in different individuals from 60° to 65°. The base of the sacrum was found by Nägele in a large number of well-formed female bodies to be about 3¾ inches above the upper margin of the symphysis pubis; the level of the top of the coccyx he found varying from 22 lines above the apex of the pubic arch to 9 lines below the same point, and on an average to be 7 or 8 lines above it (Nägele, "Das weibliche Becken," &c., Carlsruhe, 1825; Wood, article "Pelvis" in the Cyclopædia of Anatomy and Physiology). The pelvic aspect of the sacrum, near its base, looks much more downwards than forwards, hence the sacrum appears at first sight to occupy the position of the keystone of an arch; but being in reality broader at its pelvic than on its dorsal aspect, it is a key-stone inverted or having its broad end lowest, and is only supported in its place by cartilage and ligaments. The line of pressure of the weight of the body on the sacrum is directed downwards towards the symphysis pubis, and the resistance of the head of the thighbone on each side is directed upwards and inwards: hence in the most frequent deformities of the pelvis,

Fig. 89.

Fig. 90.



Figs. 89 and 90.

SKETCHES OF THE MALE AND FEMALE PELVIS. ¼

As seen from above and in front, or at right angles to the brim of the true pelvis: designed farther to illustrate the differences of the male and female form, and showing in the lower figure of the female pelvis the lines in which the dimensions of the pelvis are usually measured; (these lines are only marked on the brim of the pelvis).

a, *p*, antero-posterior or conjugate diameter; *t*, *r*, transverse or widest diameter; *o*, *b*, *o*, *b*, oblique diameters.

In the original specimens, which were selected as giving the full average dimensions, the following were the measurements in inches:—

Antero-posterior or conjugate diameter—female, 4½; male, 4. Transverse diameter—female, 5¼; male, 4¾. Oblique diameter—female, 5; male, 4¼.

arising from insufficient strength of its walls, the sacrum is projected into the inlet of the pelvis, and the acetabula approach the middle line, while the pubic bones are pressed forwards and downwards between them.

The *axis of the pelvis* is the name given to a line drawn in the middle at right angles to the planes of the brim, cavity and outlet. The posterior wall, formed by the sacrum and coccyx, being about five inches long and

Fig. 91.

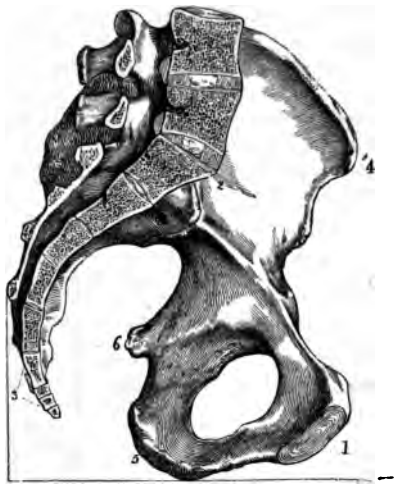


Fig. 91.—VERTICAL ANTERO-POSTERIOR SECTION OF A FEMALE PELVIS, MADE THROUGH THE SYMPHYSIS PUBIS AND MIDDLE OF THE SACRUM AND COCCYX, SHOWING THE LEFT LATERAL HALF (reduced from Nägele's figure). ⅓

1, symphysis pubis; 2, base of the sacrum and promontory; 3, coccygeal bones; 4, anterior superior spine of ilium; 5, tuberosity of ischium; 6, spine of ischium (the obturator foramen is not represented so pointed below as it generally is in females). The vertical and horizontal lines in the lower part of the figure serve as standards of comparison for the degree of inclination of the pelvis, as illustrated by the next figure.

Fig. 92.

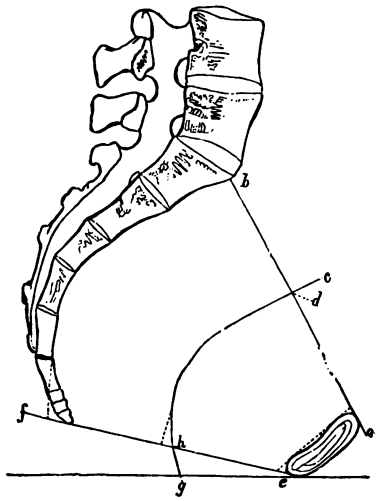


Fig. 92.—SKETCH OF PART OF THE PRECEDING FIGURE, SHOWING THE INCLINATION OF THE BRIM OF THE PELVIS AND ITS AXIS IN THE ERECT POSTURE. ⅓

a, *b*, line of inclination of the brim of the true pelvis from above the symphysis pubis to the promontory of the sacrum: *e*, *f*, a line inclining backwards and upwards, touching the lower edge of the symphysis pubis and point of the coccyx; *c*, *d*, axis of the brim at right angles to the plane of the brim; from *d* to the dotted line at right angles to *e f*, curved axis of the cavity continued into that of the outlet of the osseous pelvis; *h*, *g*, axis of the outlet of the pelvis when the soft parts are combined.

concave, while the anterior wall at the symphysis pubis is only one and a half or two inches long; the axis is curved: it is directed at the inlet upwards and forwards towards the umbilicus, and at the outlet downwards and a little forwards. The curvature of the axis of the pelvis is specially important as indicating the course in which the child's head is propelled in the process of parturition; and it may be mentioned that in the female pelvis with the soft parts entire, the axis of the outlet is curved much more forwards than in the skeleton, the

posterior wall being prolonged in that direction by the integuments of the perinæum.

Differences according to Sex.—The size and form of the pelvis differ remarkably in the two sexes. In the female the constituent bones are more slender and less marked with muscular impressions; the perpendicular depth is less, and the breadth and capacity greater: the ilia are more expanded than in the male; the inlet of the true pelvis is more nearly circular, the sacral promontory projecting less into it, and is broader from side to side; the depth of the symphysis pubis is less, the pubic arch is much wider, and the space between the tuberosities of the ischia greater.

The average dimensions of the pelvis, as measured in a number of full-sized males and females, may be stated as follows, in inches :—

	Male.			Female.		
Distance between the widest part of the crests of the ilium	10 to 11			10½ to 11		
Distance between the anterior superior spines of the ilium	9½ — 10			10 — 10½		
Distance between the front of symphysis pubis and the sacral spines	6½ — 7			6½ — 7½		
True Pelvis.	Brim.	Cavity.	Outlet.	Brim.	Cavity.	Outlet.
Transverse diameter	4½	4½	3½	5¼	5	4¾
Oblique diameter	4¼	4½	4	5	5¼	4¾
Antero-posterior diameter	4	4½	3¼	4½	5¼	5

THE FEMUR.

The femur or thigh bone, the largest bone of the skeleton, is situated between the os innominatum and the tibia. In the erect position of the body it inclines inwards and slightly backwards as it descends, so as to approach inferiorly its fellow of the opposite side, and to have its upper end a little in advance of the lower. It is divisible into a superior extremity including the head and neck and two eminences called trochanters, the shaft, and an inferior extremity expanded into an external and internal condyle.

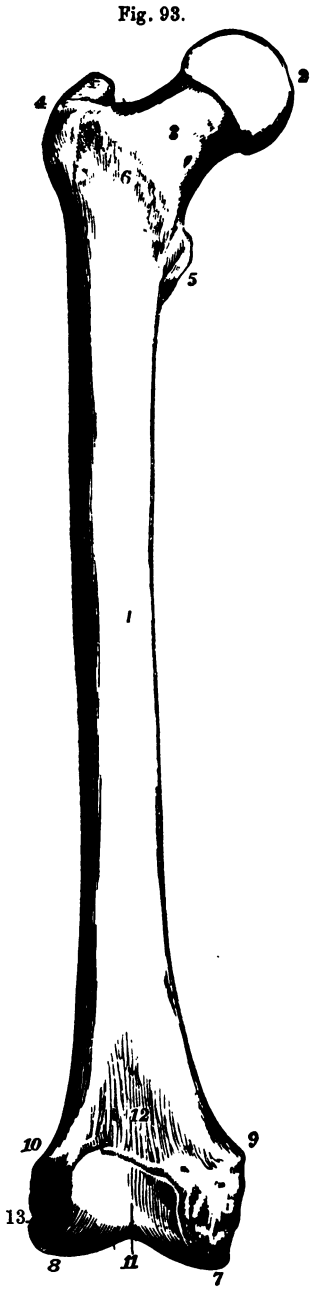
At the *superior extremity* of the bone, the *neck* extends inwards and upwards, and has a slight inclination forwards from the shaft. It has a constricted appearance, and its diameter from before backwards is less considerable than in the vertical direction, in which last greater strength is required to sustain the weight of the body. Its superior surface is shortest; its inferior surface longest, and the anterior shorter than the posterior. The *head*, forming more than half a sphere, covered with cartilage in the fresh state, surmounts the neck, and is articulated with the acetabulum. Beneath its most prominent point is a small depression or pit, which gives attachment to the round ligament of the hip joint.

The *trochanter major* is a thick truncated process prolonged upwards in a line with the external surface of the shaft. In front it is marked by the insertion of the gluteus minimus; externally an oblique line directed downwards and forwards indicates the inferior border of the insertion of the gluteus medius muscle, and lower down a horizontal line, continued upwards in front of the trochanter, marks the upper limit of the vastus externus.

Internally at its base, and rather behind the neck, is the *trochanteric* or *digital*

Fig. 93.—Femur of a Male from before. ½

1, shaft; 2, head; 3, neck; 4, great trochanter; 5, small trochanter; 6, anterior intertrochanteric line; 7, internal articular condyle; 8, external articular condyle; 9, internal tuberosity; 10, external tuberosity; 11, the patellar articular surface; above it 12, the flat part of the femur sometimes called the suprapatellar surface; 13, the depression for the tendon of the popliteus muscle.



fossa, which gives attachment to the obturator externus muscle. The posterior border of the great trochanter is prominent, and continued into a smooth elevation, the *posterior inter-trochanteric line*, which passes downwards and inwards to the small trochanter, and limits the neck posteriorly. The *small trochanter*, a conical rounded eminence, projects from the posterior and inner aspect of the bone, and gives attachment to the tendon of the psoas and iliacus muscles. The *anterior trochanteric line* is a rough ridge limiting the neck in front between the two trochanters; it indicates the superior border of the crureus and vastus internus muscles, and is continuous beneath the great trochanter with the line which limits the vastus externus.

The *shaft* is slightly arched from above downwards, with the convexity forwards. It is expanded at its upper and lower ends. Towards the centre it is nearly cylindrical, but with an inclination to the prismatic form. Its anterior and lateral surfaces, smooth and uniform, are covered by the crureus and vasti muscles. The elevation which separates the anterior from the internal surface is at the upper part strongly marked and inclined forwards, giving the appearance to the bone as if the forward inclination of the neck were produced by a twisting outwards of the upper end of the shaft. The lateral surfaces in the middle of their extent approach one another behind, being only separated by the linea aspera. The *linea aspera* is a prominent ridge, extending along the central third of the shaft posteriorly, and bifurcating above and below. It inclines slightly inwards in the middle, so as to make the external

surface of the shaft seem concave in that part. It presents two sharp

Fig. 94.

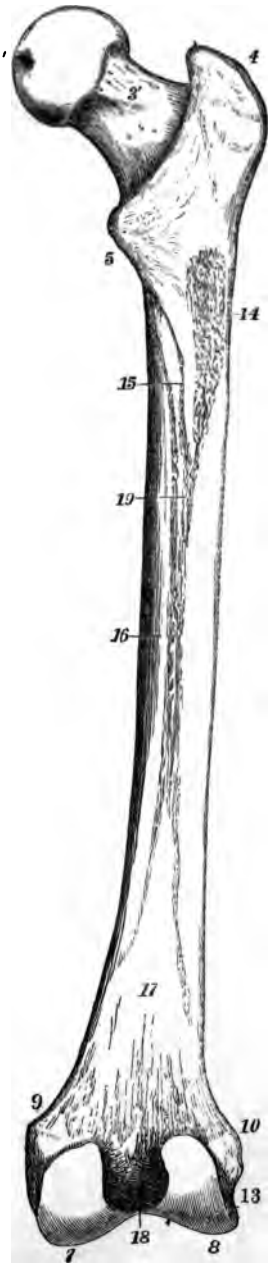


Fig. 94.—Femur of a Male from behind. ½

4, 5, 7, 8, 9, 10 and 13, the same as in the preceding figure; 2', pit on the head for the round ligament of the hip-joint; 3', the back of the neck, showing a slight groove of the obturator externus muscle as it passes over the capsular ligament and neck; 14, rough impression of the attachment of the gluteus maximus muscle in the upper and outer continuation of the linea aspera; 15, two lines running up towards the lesser trochanter from the linea aspera, marking the attachments of the adductor brevis and pectineus muscles; 16, flat elevated surface of the linea aspera; 17, flat triangular popliteal surface between the lower divisions of the linea aspera; 18, intercondyloid or crucial notch; 19, foramen for the nutritious or medullary vessels.

margins and a flat interval. The external division of its superior bifurcation passes up to the great trochanter, and in its course is strongly marked where the gluteus maximus is attached; the internal division terminates in front of the small trochanter. The inferior divisions terminate at the tuberosities of the condyles, and enclose between them a flat triangular surface of bone, which is free from muscular attachments, and forms the floor of the upper part of the popliteal space. Towards the superior part of the linea aspera is the foramen for the medullary vessels directed upwards into the bone.

The *inferior extremity* presents two rounded eminences, the *condyles*, united anteriorly, but separated posteriorly by a deep *inter-condyloid fossa*. Their greatest prominence is directed backwards, and their curve, as it increases towards that part, may be compared to that of a partially uncoiled piece of watch-spring. The external condyle is the broadest and most prominent in front; the internal is the longest and most prominent inferiorly. One large articular surface, coated continuously with cartilage, extends over both condyles, but opposite the front of the inter-condyloid fossa it is divided by two slight linear depressions into three parts, an elevated surface on each side of the fossa for articulation with the tibia; and a grooved anterior surface for the patella. The patellar surface is of a trochlear form, being marked by a vertical hollow; the external portion of this surface is the most prominent, and rises highest.

The tibial surfaces are nearly parallel, except in front, where the internal turns obliquely outwards to reach the patellar surface. Above the condyles are two rough tuberosities, one on each side of the bone, which give attachment to the external and internal lateral ligaments of the knee joint. Between the external tuberosity and the back part of the external condyle is a smooth groove directed downwards and forwards, and ending anteriorly in a pit, in which the popliteus muscle takes origin.

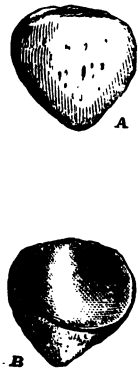
In the female the angle made by the neck of the femur with the shaft is less obtuse than in the male; and from the greater width of the pelvis, and the shortness of the limbs, the convergence of the thigh bones inferiorly is more apparent.

THE PATELLA.

The patella, *rotula*, or knee-pan, is situated at the front of the knee joint, is attached inferiorly by a ligament or tendon to the tibia, and may be considered as a sesamoid bone developed in the tendon of the quadriceps extensor cruris. It is compressed from before backwards, and has the form of a triangle with the apex below. Its anterior surface is subcutaneous; its superior border is broad, and gives attachment to the extensor muscles; its inferior angle, together with a rough depression on its deep aspect, gives attachment to the ligamentum patellæ. The deep surface, except at the inferior angle, is coated with cartilage for articulation with the femur, and is divided by a vertical elevation into two parts, the external of which is largest and is transversely concave, while the internal is convex.

Fig 95.—Right Patella. ½

Fig. 95.



A from before; B from behind.

Both views show the lower extremity pointing slightly inwards; the posterior view shows the articular cartilaginous surface, divided by an elevated ridge into a smaller internal and a larger external part.

THE TIBIA.

The tibia, or shin bone, is, next to the femur, the longest bone in the skeleton. It is the anterior and inner of the two bones of the leg, and alone communicates the weight of the trunk to the foot. It articulates with the femur, fibula, and astragalus.

The *superior extremity* is thick and expanded, broader from side to side than from before backwards, and slightly hollowed posteriorly. On its superior aspect are placed two slightly concave articular surfaces, which sustain the femur. These are the *condyloid surfaces;* they are oval in form, the external being widest transversely, and the internal longest from before backwards. Between them is an irregular interval, depressed in front and behind, where it gives attachment to the crucial ligaments and semilunar cartilages of the knee joint, and elevated in the middle, where is formed the *spine*. The summit of the spine presents two prominent tubercles, which are formed by the prolongation upwards on its sides of the margins of the condyles; that of the outer condyle being turned slightly forwards, and that of the inner more slightly backwards. On the sides of the upper extremity of the bone are two rounded eminences, the *external* and *internal tuberosities*; the outer one of these,

somewhat smaller than the other, is marked posteriorly by a flat surface which articulates with the fibula, while the inner presents a groove for the insertion of the semi-membranosus muscle. Lower down, in front, is situated the *anterior tuberosity* or *tubercle*, rough inferiorly, where it gives attachment to the ligamentum patellæ, and smooth above, where it is covered by a synovial bursa.

Fig. 96.

Fig. 96.—Right Tibia from before. ⅛

1, shaft, and shin or anterior border; 2, inner tuberosity; 3, outer tuberosity; 4, inner, and 5, outer, condyloid articular surface; 6, crucial spine, with fossa at its root in front; 7, anterior tuberosity or tubercle; 8, lower articular surface for astragalus; 9, malleolus internus.

The *shaft* of the tibia is three-sided, and diminishes in size as it descends for about two-thirds of its length, but increases somewhat towards its lower extremity. The *internal surface* is convex and subcutaneous, except at the upper part, where it is crossed by the tendons of the sartorius, gracilis, and semitendinosus muscles. It is separated from the external surface by a sharp subcutaneous, slightly sinuous *crest*, the shin ridge, which descends from the anterior tuberosity, and is smoothed away in the inferior third of the bone. The *external surface* is slightly hollowed in the larger part of its extent, where it gives origin to the tibialis anticus muscle; but beneath the point where the crest disappears it turns forwards, becomes convex, and is covered by the extensor tendons. The *posterior surface* is traversed obliquely in its upper third by the *popliteal line*—a rough mark which extends upwards and outwards to the external tuberosity, giving attachment to the soleus muscle, and separating a triangular area, in which the popliteus muscle lies, from the space below, which gives origin to the flexor longus digitorum and tibialis posticus. Internally, the posterior surface is separated from the internal by a smooth rounded border; while on its external side is a sharp ridge, inclined forwards above, to which the interosseous membrane is attached. Near the popliteal line is a large medullary foramen, directed downwards into the interior of the bone.

The *inferior extremity*, much smaller than the superior, is expanded transversely, and projects downwards on its inner side, so as to form a thick process, the *internal malleolus*. Inferiorly it presents for articulation with the astragalus a cartilaginous surface, which is quadrilateral, concave from before backwards, and having its posterior border narrower and projecting

farther downwards than the anterior; internally the cartilaginous surface is continued down in a vertical direction upon the internal malleolus, clothing its outer surface somewhat more deeply in front than behind. The external surface, slightly concave, is rough superiorly for ligament, and smooth below for articulation with the fibula. The posterior surface is marked by a double groove on the internal malleolus for the tendons of the tibialis posticus and flexor longus digitorum, and more externally by a slight depression where the flexor longus pollicis lies; the inner surface of the internal malleolus is subcutaneous.

Fig. 97.—Right Tibia from behind. ½

6, and 9, as in the preceding figure; 2′, groove behind the internal tuberosity for the tendon of the semi-membranosus muscle; 10, inclined articular facet below and behind the outer tuberosity for the head of the fibula; 11, oblique line of tibia, above which is the triangular popliteal surface; 12, foramen directed downwards for the nutritious or medullary vessels; 13, triangular rough surface for the lower interosseous ligament and small cartilaginous surface below it for articulation with the fibula; 14, below a slight groove marking the place of the flexor longus pollicis muscle; 15, below the groove of the tendons of the flexor communis digitorum and tibialis posticus muscles, behind the malleolus internus.

Fig. 97.

The tibia is slightly twisted, so that when the internal malleolus is directed inwards, the internal tuberosity is inclined backwards—a conformation which deserves attention in the diagnosis and adjustment of fractures.

THE FIBULA.

The fibula, or *peroneal bone*, is situated at the external side of the leg: it is nearly equal to the tibia in length, but is much more slender. Its inferior extremity is placed a little in advance of the upper; and its shaft is slightly curved, so as to have the convexity directed backwards, and, in the lower half, slightly inwards towards the tibia.

The *superior extremity*, or *head*, somewhat expanded, presents a small oval cartilaginous surface looking upwards and inwards, which articulates with the external tuberosity of the tibia, and externally to this a rough prominence directed upwards, to which the tendon of the biceps muscle is attached: its external surface is subcutaneous; the rest is rough for ligaments.

The *inferior extremity*, or *external malleolus*, is larger than the head of the bone, and longer and more prominent than the internal malleolus; internally it forms the outer limit of the ankle-joint, and presents a triangular smooth surface for articulation with the astragalus, bounded posteriorly by a rough depression where the transverse ligament is attached: its anterior

border, after projecting rather abruptly forwards, slopes downwards and backwards; its posterior border presents a shallow groove traversed by the tendons of the peronei muscles; while externally it is convex and subcutaneous, and a triangular subcutaneous surface is continued up from it for an inch or two on the shaft.

Fig. 98. Fig. 99.

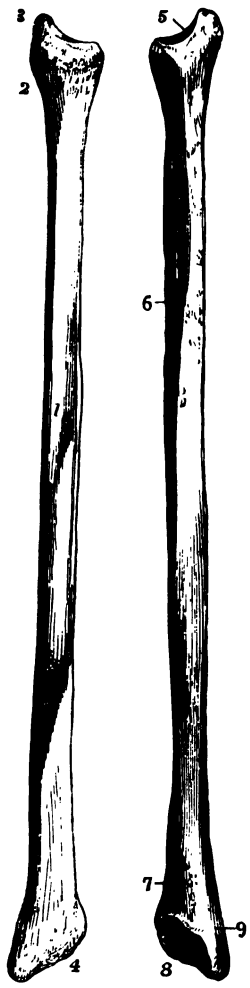


Fig. 98.—RIGHT FIBULA FROM THE OUTSIDE AND BEFORE. ½

1, shaft, outer and anterior surface, showing the oblique grooves of the peronei muscles; 2, head; 3, its projection, giving insertion to the tendon of the biceps femoris; 4, malleolus externus or lower end, the figure is placed opposite its anterior or oblique edge; above this is seen the triangular subcutaneous surface of the bone.

Fig 99.—RIGHT FIBULA FROM THE INSIDE AND BEHIND. ½

5, the oblique surface of articulation with the tibia superiorly; 6, points to the internal or interosseous ridge; 7, the triangular rough surface for the lower interosseous ligament; 8, the external malleolar surface for articulation with the astragalus; 9, groove behind the malleolus externus for the tendons of the peronei muscles.

The *shaft* is irregularly four-sided and twisted. One surface, from which the peronei muscles take origin, looks forwards at the commencement, then turning outwards and backwards is continued behind the subcutaneous space of the lower end to the groove behind the malleolus. Another surface looking backwards in the upper half of its extent, winds inwards and terminates above the articular surface of the malleolus; near its upper end this surface is rough, giving attachment to the soleus muscle, and in the rest of its extent it is occupied by the flexor longus pollicis. The remaining part of the surface of the bone, internal, turns forwards inferiorly, and terminates on the anterior margin of the malleolus: it is divided by a longitudinal line to which the interosseous ligament is attached, into a posterior and upper part, which gives origin to the tibialis posticus, and an anterior and lower part, from which arise the long extensors of the toes and the peroneus tertius, the interosseous membrane being attached to the line between these surfaces. About the middle of the posterior surface is the medullary foramen directed downwards into the bone.

THE TARSUS.

The tarsus is composed of seven bones, viz., the os calcis, astragalus, cuboid, scaphoid, and three cuneiform.

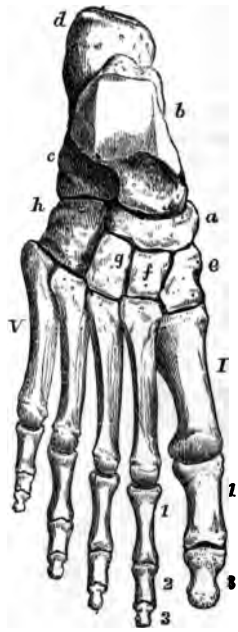
THE CALCANEUM.

The calcaneum, or *os calcis*, is the largest bone of the foot. Projecting downwards and backwards it forms the heel. Above it articulates with the astragalus, and in front with the cuboid bone. Its principal axis extends forwards and outwards from its posterior extremity to the cuboid bone.

Fig. 100.—RIGHT FOOT VIEWED FROM ABOVE, SHOWING ITS DORSAL ASPECT. ⅓

a, scaphoid bone; *b*, astragalus; *c*, os calcis; *d*, its great tuberosity; *e*, internal or first cuneiform; *f*, middle cuneiform; *g*, external cuneiform; *h*, cuboid bone. I to V, the series of metatarsal bones; 1, 3, first and terminal phalanges of the great toe; 1, 2, 3, are placed opposite to the first, second, and terminal phalanges of the second toe.

Fig. 100.



The large posterior extremity, or *tuber calcis*, presents inferiorly two *tubercles*, which rest upon the ground, and the internal of which is largest: the rest of its surface, looking backwards, is divided into a lower part, which receives the attachment of the tendo Achillis, and an upper part, smooth and less prominent, separated from that tendon by a synovial bursa. The part in front of the tuber forms a slightly constricted *neck*. The internal surface of the bone, traversed by the plantar vessels and nerves and the flexor tendons, is deeply concave, and its concavity is surmounted in front by a flattened process, the *sustentaculum tali*, which projects inwards near the anterior extremity of the bone, in a line with its upper surface, and presents inferiorly a groove occupied by the tendon of the flexor longus pollicis. The superior surface presents two articular facets for the astragalus: the anterior of these is placed over the sustentaculum, and is flat; the other, external and posterior to this, and larger, is separated from it by a rough furrow, giving attachment to the interosseous ligament, and is convex from without inwards and backwards. In front of this latter facet is a rough depression, from which the extensor brevis digitorum takes origin. The anterior extremity articulates, by a surface slightly concave in the vertical and convex in the transverse direction, with the cuboid bone; and internal to this, in front of the sustentaculum tali, it gives attachment to the inferior calcaneo-scaphoid ligament. The inferior surface, projecting in a rough anterior tubercle, gives attachment to the calcaneo-cuboid ligaments. The external surface is subcutaneous, and on the whole smooth, but presents in its fore-part superficial grooves traversed by the tendons of the peronei muscles.

THE ASTRAGALUS.

The astragalus or *talus*, irregular in form, receives the weight of the body from the leg. It articulates with the tibia and fibula above, the os calcis below, and the scaphoid in front. Its longest axis is directed forwards and inwards. Its convex anterior extremity is called the *head*, and the circular groove behind it the *neck*. The superior articular surface, placed behind

the neck, consists of a middle and two lateral parts. The middle part, looking upwards to the tibia, is convex from before backwards, broader in front than behind, with its outer margin higher and longer than the inner, and curved, while the inner is straight. The inner lateral part is narrow, and articulates with the internal malleolus; the outer lateral part, much deeper, articulates with the external malleolus. Inferiorly, there are two smooth surfaces, which articulate with the calcaneum. The posterior of these, the largest, concave from within outwards and forwards, is separated by a rough depression for the interosseous ligament from the flat anterior surface, which rests on the sustentaculum tali. The anterior margin of this surface is continuous with the rounded surface of the head, which articulates with the scaphoid bone. The posterior border of the bone lies behind the sustentaculum tali, and, like that process, is grooved by the tendon of the flexor longus pollicis.

Fig. 101.

Fig. 101.—RIGHT FOOT VIEWED FROM BELOW, SHOWING THE PLANTAR ASPECT. ⅓

The indications are the same as in the preceding figure; the middle and external cuneiform bones are not lettered; the sesamoid bones are not represented; they will be seen in the view of the articulations of the foot.

THE CUBOID BONE.

This bone is situated at the outer side of the foot, between the calcaneum and the fourth and fifth metatarsal bones. It deviates from the cuboid form and becomes rather pyramidal by the sloping of four of its surfaces towards the smaller external border. The posterior surface articulates with the os calcis, the anterior surface, also covered with cartilage, is divided into an internal quadrilateral and an external triangular facet, articulating with the fourth and fifth metatarsal bones. On the internal surface, in the middle, and touching its superior border, is a smooth surface, which articulates with the external cuneiform bone, and behind this, in some instances, a smaller surface articulating with the scaphoid, while the remainder is rough for ligaments. The external border presents a vertical groove, in which the tendon of the peroneus longus lies; and the inferior surface is traversed obliquely near its anterior margin by a continuation of the same groove; behind this there is a thick ridge, which, with the rest of the inferior surface, gives attachment to the calcaneo-cuboid ligaments. The superior surface looking outwards and upwards, is on the whole even, but rather rough.

THE SCAPHOID BONE.

The scaphoid or *navicular* bone is placed at the inner side of the foot, between the astragalus and cuneiform bones. It is short from behind forwards, and broad from side to side. It presents posteriorly an articular concavity for the head of the astragalus, and anteriorly a convex surface divided, by two lines converging below, into three facets which articulate

respectively with the three cuneiform bones. On its outer side, in some instances, is a small smooth surface, by which it is articulated to the cuboid bone. Its superior and inferior surfaces are rough, and on its inner border, directed downwards, is a prominent *tubercle* to which the tendon of the tibialis posticus muscle is attached.

THE CUNEIFORM BONES.

These wedge-shaped bones, three in number, are distinguished numerically according to their order from within outwards. They intervene between the scaphoid bone and the three inner metatarsal bones, and present anteriorly and posteriorly smooth surfaces for articulation with those bones. The first or internal cuneiform bone is the largest; it is narrow above, and thick and rough towards the sole; its dorsal surface looks inwards and upwards, and is marked by an oblique descending groove, in which the tendon of the tibialis anticus lies; its external surface, concave and rough inferiorly, is smooth and articular above. The second and third, or middle and external, cuneiform bones each present a quadrangular surface superiorly, and a narrower rough edge below, contributing thus to form the transverse arch of the foot. The proximal ends of the three bones are in the same transverse line; but as the middle bone is the shortest, the internal and external project forwards, so as to articulate laterally not only with the sides of that bone, but also with the base of the second metatarsal bone, which is inserted between them. The outer side of the third cuneiform articulates by a smooth flat surface with the cuboid, and by a small narrow facet (sometimes absent) with the fourth metatarsal bone.

THE METATARSUS.

The five metatarsal bones are distinguished by numbers, according to their position from within outwards.

They resemble the metacarpal bones of the hand in being shafted bones, slightly convex from behind forwards on the dorsal aspect, and having irregularly shaped proximal extremities, three-sided shafts, and rounded *heads* which articulate with the phalanges. The first metatarsal bone is much thicker and more massive, though shorter than any of the rest. The others diminish in length from the second to the fifth.

The *proximal extremities* resemble those of the metacarpal bones exactly as regards the number of bones with which each articulates. The first articulates with one bone, the internal cuneiform; the second with four bones, viz. the three cuneiform and the third metatarsal; the third with three bones, viz. the external cuneiform and the adjacent metatarsals; the fourth with four bones, viz. the cuboid, external cuneiform, and the adjacent metatarsals; the fifth with two bones, viz. the cuboid and the fourth metatarsal. The fourth, however, is sometimes connected with only three bones, its facet for articulation with the external cuneiform being absent. The tarsal extremity of the first metatarsal bone presents a slightly concave articular surface, and is broad below and narrow above. That of the fifth presents externally a large rough tuberosity which projects beyond the other bones at the outer side of the foot; and the line of its articulation with the cuboid bone is so oblique that, if prolonged inwards, it would reach the digital end of the first metatarsal bone. The tarsal ends of the remaining three bones are broad and flat above, rough and narrower below, and by their wedge-like form assist in producing the transverse arch of the foot.

The *shafts* present in the greater part of their extent a prominent border

looking upwards, which in the middle three projects between the dorsal interosseous muscles on each side.

The *heads*, smaller than the tarsal extremities, are marked on their sides by depressions and tubercles. Their articular surfaces, smooth and convex, are prolonged on the inferior aspect, where they terminate in bifid margins. That of the first metatarsal bone presents inferiorly a ridge in the middle, with grooved depressions placed one on each side and corresponding to the position of the sesamoid bones.

THE PHALANGES.

The phalanges of the toes so closely correspond in general conformation with those of the fingers that it will only be necessary in this place to state the points in which they differ from the latter.

The phalanges of the four outer toes are much smaller than the corresponding phalanges of the hand; but those of the great toe are larger than those of the thumb. The shafts of the first row of phalanges in the four outer toes are compressed laterally and narrowed in the middle; those of the second row, more especially the fourth and fifth, are very short, and consist of little beyond what is necessary to unite their articular extremities. The last two phalanges of the little toe are in adults not unfrequently connected by bone into one piece.

Sesamoid Bones.—Two sesamoid bones lie side by side in the plantar wall of the first metatarso-phalangeal joint, and glide in the grooves on the head of the first metatarsal bone. Small sesamoid bones sometimes occur in the corresponding joints of the other toes.

THE BONES OF THE FOOT AS A WHOLE.

The foot is narrowest at the heel, and as it passes forwards becomes broader as far as the heads of the metatarsal bones. The posterior extremity of the calcaneum is inclined inwards and backwards. The astragalus, overhanging the sustentaculum tali, inclines inwards from the calcaneum so much that its external superior angle is directly over the middle line of the calcaneum, and hence the internal malleolus appears more prominent than the external. The foot is arched from behind forwards, the posterior pier of the arch being formed by the heel, the anterior by the balls of the toes. The arch, indeed, may be considered as double in front, with a common support behind. The internal division of the arch is that which bears the greater part of the weight of the body, and is most raised from the ground; it consists of the calcaneum in its posterior two thirds, the scaphoid and cuneiform bones, and the three inner toes; the outer arch is formed by the calcaneum in its whole length, the cuboid bone, and the fourth and fifth toes, a great part of which rests upon the ground in standing. Besides being arched longitudinally, the foot presents likewise a transverse arch formed by the cuboid and three cuneiform bones and the metatarsal bones.

DEVELOPMENT OF THE LOWER LIMB.

The early stages of development in the lower limbs are similar to those which have been already described in connexion with the upper.

Ossification.—*The innominate bone* is formed from the three principal pieces previously mentioned, viz., the ilium, ischium, and os pubis, and various others of an epiphysial nature. The deposit of bone commences in the cartilaginous piece of the ilium a little later than in other large bones; it is followed by that in the ischium, and still later by that in the pubis. One epiphysis extends over the whole length of the crest of the ilium; a second covers the tuberosity of the ischium, passing forwards

over the greater part of the ramus; a third, inconstant, is placed on the anterior inferior spine of the ilium; and a fourth, likewise inconstant, at the symphysis pubis. Moreover, between the extremities of the three principal osseous pieces, where they meet in the acetabulum, there is situated in early life a thin stratum of cartilage, which becomes ossified from one or more centres, and presents the shape of the letter Y.

Fig. 102.

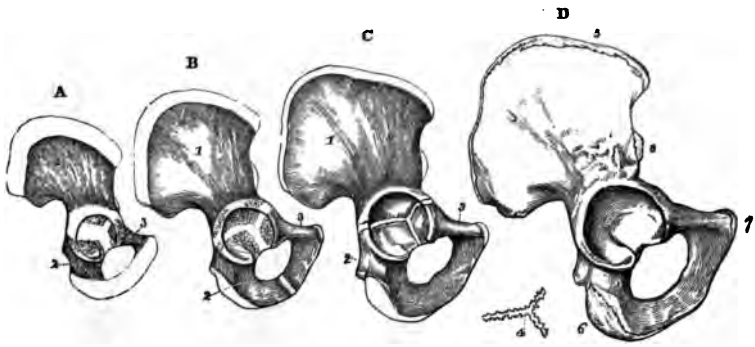


Fig. 102.—Ossification of the Os Innominatum.

A, the condition of the bone at birth. Bone has spread from three nuclei into the ilium, ischium, and pubis, which meet in the cartilage of the acetabulum.

B, the bone of a child under six years of age. The rami of the ischium and pubis are farther ossified, but still separate.

C, a bone of two or three years later, in which the rami are united.

D, the bone of the right side from a person of about twenty years. Union has taken place in the acetabulum, and the additional epiphyses are seen on the crest of the ilium, the anterior inferior spine, the ischial tuberosity, and the margin of the symphysis pubis.

In A, B and C, 1, ilium; 2, ischium; 3, pubis; under D, 4, Y-shaped piece formed of several fragments which begin to ossify about the 14th year, and often unite into this form before the completion of the acetabulum; 5, epiphysis of the crest; 6, that of the tuberosity of the ischium; 7, that of the symphysis pubis; 8, that of the anterior inferior spine of the ilium.

The *pelvis* of the fœtus and young child is of very small capacity proportionally to the size of the body, and those viscera which are afterwards contained for the most part in the true pelvis occupy a part of the abdominal cavity. The obliquity of the pelvis is considerably greater in early life than in the adult.

The *femur* is developed from one principal ossific centre for the shaft and from four epiphyses, which appear in the following order:—a single nucleus for the lower extremity, one for the head, one for the great trochanter, and one for the small; these epiphyses become united to the main part of the bone in an order of time the reverse of that in which they appear.

The *tibia and fibula* each present, besides the principal centre of ossification for the shaft, a superior and an inferior epiphysis. In the tibia the superior epiphysis appears first, and it not only includes the lateral tuberosities, but sends down a process in front, extending into the anterior tuberosity. In the fibula the inferior epiphysis is the first to appear, and in both bones the inferior epiphyses are first united to the shaft.

The *tarsal bones* are ossified each from a single nucleus, with the exception of the os calcis, which, in addition to its principal osseous centre, has an epiphysis incrusting the upper part of its posterior extremity.

The *metatarsal bones and phalanges* agree respectively with the corresponding bones in the hand, in the mode of their development. Each bone is formed from a principal piece and one epiphysis; and while in the four outer metatarsal bones the epiphysis is at the distal extremity, in the metatarsal bone of the great toe and in the phalanges it is placed at the proximal extremity.

PERIODS OF OSSIFICATION OF THE BONES OF THE LOWER LIMB.

I. *Os Innominatum.*

The chief nucleus of the ilium appears in the 8th or 9th week.
The chief nucleus of the ischium appears in the 3rd month.
The chief nucleus of the pubis appears from the 4th to the 5th month.
Ossification in the Y-shaped cartilage of the acetabulum appears about puberty; and in the epiphyses of the iliac crest, anterior inferior spinous process, ischial tuberosity, and symphysis pubis, somewhat later.
The rami of the pubis and ischium unite about the 7th or 8th year.
The parts which meet in the acetabulum unite about the 16th or 17th year.
The main bone and epiphyses unite about the 25th year.

Fig. 103.

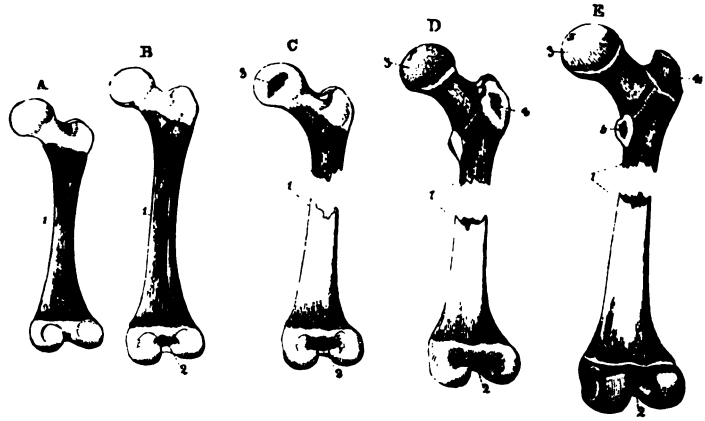


Fig. 103.—Ossification of the Femur.

A, femur of a fœtus of about eight months; the body is osseous; both ends are cartilaginous.
B, femur of a child at birth, showing a nucleus in the lower epiphysis.
C, femur of a child of about a year old, showing a nucleus in the articular head.
D, femur of the fifth or sixth year. Ossification has extended from the shaft into the neck, and a nucleus has appeared in the great trochanter.
E, femur of about the age of puberty, showing more complete ossification and a nucleus in the lesser trochanter.
1, shaft; 2, lower extremity; 3, head; 4, great trochanter; 5, small trochanter.

II. *Femur.*

The nucleus of the shaft appears in the 7th week.
The nucleus of the lower epiphysis appears in the 9th month.
The nucleus of the head appears at the end of the 1st year.
The nucleus of the great trochanter appears in the 4th year.
The nucleus of the small trochanter appears in the 13th or 14th year.
The small trochanter and shaft unite about the 17th or 18th year.
The great trochanter and shaft unite about the 18th year.
The head and shaft unite about the 18th or 19th year.
The lower epiphysis and shaft unite after the 20th year.

III. *Tibia.*

The nucleus of the shaft appears in the 7th week.
The upper epiphysis appears sometimes before, sometimes after birth.

Fig. 104.

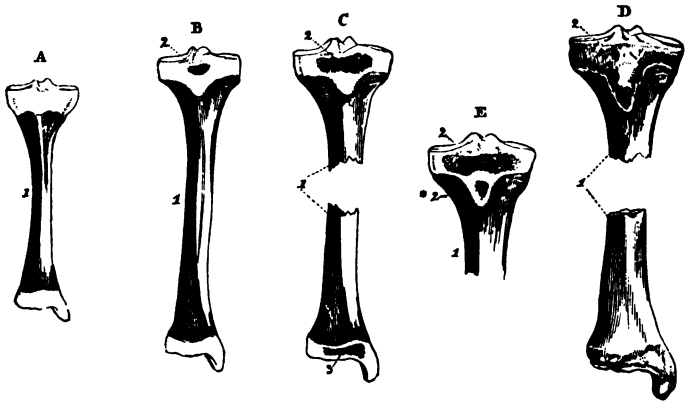


Fig. 104.—Ossification of the Tibia.

A, tibia of a fœtus some weeks before birth; the shaft is ossified; the ends are cartilaginous.

B, tibia of a child at birth, showing the commencement of a nucleus in the upper epiphysis.

C, tibia of the third year, showing the nucleus of the lower epiphysis.

D, tibia of about eighteen or twenty years, showing the united condition of the lower epiphysis, while the upper remains separate. The upper epiphysis is seen to include the anterior tuberosity.

E shows an example of a separate centre for the anterior tuberosity.

1, shaft; 2, superior epiphysis; 2*, separate centre for the anterior tuberosity; 3, inferior epiphysis.

Fig. 105.

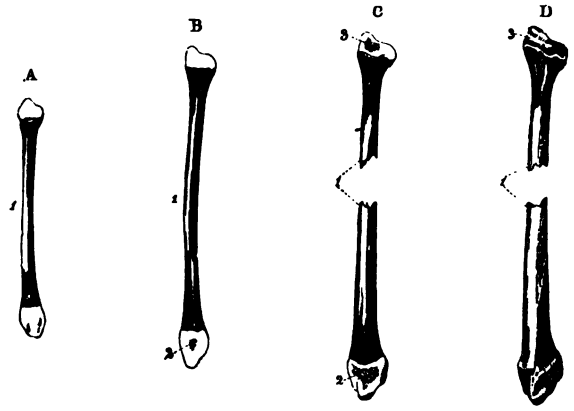


Fig. 105.—Ossification of the Fibula.

A, fibula from a child at birth. The shaft ossified; the ends cartilaginous.

B, fibula from a child of two years, showing a nucleus in the lower epiphysis.

C, the bone of a child of about four years, showing the nucleus of the upper epiphysis; the lower ought to have been shown as more advanced.

D, fibula of a person of about twenty years, in which the lower end is complete, but the upper epiphysis is still separate.

1, shaft; 2, lower epiphysis; 3, upper epiphysis.

Fig. 106.

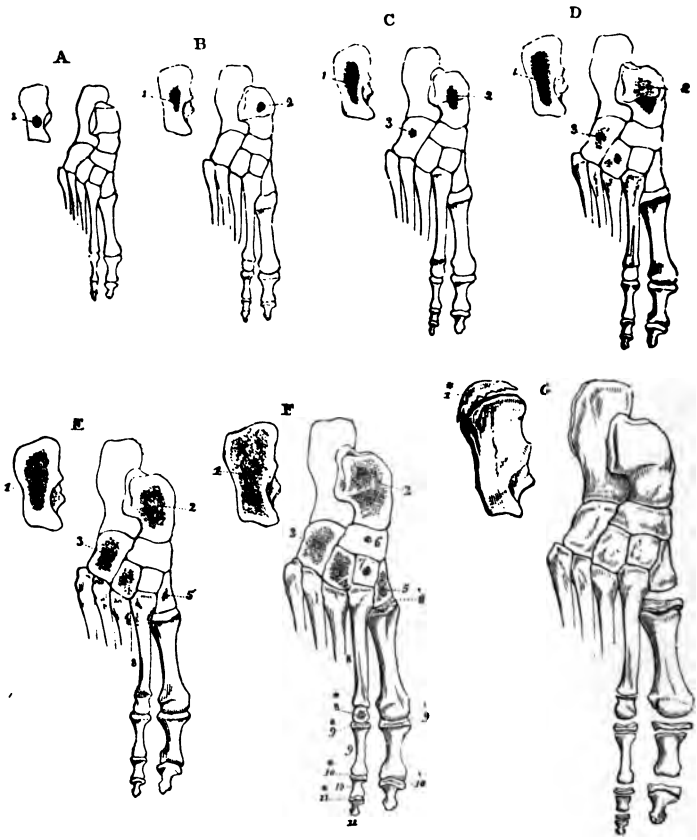


Fig. 106.—Ossification of the Bones of the Foot.

A, right foot of a fœtus of six months. The metatarsal bones and digital phalanges have each their shafts ossified from their primary centres; the tarsus is wholly cartilaginous, excepting the os calcis, in which the nucleus of bone has just appeared.

B, foot of a fœtus of from seven to eight months. The astragalus shows an osseous nucleus.

C, from a child at birth; the cuboid has begun to ossify.

D, from a child about a year old, showing a nucleus begun in the external cuneiform.

E, from a child in the third year; ossification has reached the internal cuneiform.

F, from a child between three and four years old, showing ossification in the middle cuneiform and scaphoid bones, and in the epiphyses of the metatarsal bones and phalanges.

G, from a person of about the age of puberty. Ossification is nearly complete in the tarsal bones; an epiphysis has been formed on the tuberosity of the os calcis, and the epiphyses of the metatarsal bones and phalanges are shown separate.

1, nucleus of the os calcis; 1* in G, the epiphysis of the os calcis; 2, nucleus of the astragalus; 3, of the cuboid; 4, of the external cuneiform; 5, of the internal cuneiform; 6, of the scaphoid; 7, of the middle cuneiform; 8, metatarsal bones; 8*, distal epiphyses of the four metatarsal bones; 8′, proximal epiphysis of the first; 9, first range of digital phalanges; 9*, proximal epiphyses of the four outer of these phalanges; 9′, that of the first phalanx of the great toe; 10, second range of phalanges; 10*, the epiphyses of these phalanges; 10′, epiphysis of the terminal phalanx of the great toe; 11, four terminal phalanges; 11*, their epiphyses.

Tibia (continued)—

The lower epiphysis appears in the 2nd year.
The lower epiphysis and shaft unite in the 18th or 19th year.
The upper epiphysis and shaft unite in the 21st or 22nd year.

IV. *Fibula.*

The nucleus of the shaft appears soon after that of the tibia.
The lower epiphysis appears in the 2nd year.
The upper epiphysis appears in the 3rd or 4th year.
The lower epiphysis and shaft unite in the 21st year or later.
The upper epiphysis and shaft unite after union of the lower epiphysis.

V. *Patella.*

Ossification begins in the 3rd year.

VI. *Tarsus.*

The nucleus of the os calcis appears in the 6th month.
The nucleus of the astragalus appears in the 7th month.
The nucleus of the cuboid bone appears at birth.
The nucleus of the external cuneiform bone appears in the 1st year.
The nucleus of the internal cuneiform bone appears in the 3rd year.
The nucleus of the middle cuneiform bone appears in the 4th year.
The nucleus of the scaphoid bone appears in the 4th or 5th year.
The epiphysis of the os calcis appears in the 10th year.
The epiphysis of the os calcis is united in the 15th or 16th year.

VII. *Metatarsus.*

The nuclei of the shafts appear in the 8th or 9th week.
The epiphyses appear in the 3rd to the 8th year.
The shafts and epiphyses unite from the 18th to the 20th year.

VIII. *Phalanges.*

The nuclei of the shafts appear in the 9th or 10th week.
The epiphyses appear from the 8th to the 10th year.
The shafts and epiphyses unite from the 19th to the 21st year.

COMPARISON OF THE UPPER WITH THE LOWER LIMB.

The general resemblance which is manifest between the upper and lower limbs is found, on a closer inspection, to result from a community of plan, which can be traced even into certain comparatively minute details, and is not confined to any one system. The details of the correspondence in many points, however, are still undetermined, and even with regard to some parts of the skeleton, variety of opinion still exists. In the hand and foot the correspondence of the bones is very plain. The palmar and plantar aspects being regarded as similar, the great toe corresponds obviously to the thumb; the four anterior tarsal bones bear a close resemblance to the four inferior carpal bones in the particulars of their metatarsal articulations; and of the remaining tarsal bones the scaphoid obviously corresponds to the bone of the same name in the hand, the astragalus to the semilunar bone, and the os calcis to the cuneiform and pisiform bones united. The great difference in the appearance of the tarsus from that of the carpus depends principally on the large development of the os calcis and astragalus, by means of which the scaphoid is thrown forward and inwards, and the aspect of the tarsus morphologically posterior, that on which the flexor tendons pass to the sole, is turned towards the inner side. If this be the correct comparison of the bones of the hand and foot, with regard to which there cannot be any doubt, it naturally follows that the tibia, lying as it does on the same side of the limb as the great toe, corresponds with the radius: a doctrine which, first laid down by De Blainville and then by Barclay, has been subsequently enunciated by Flourens and Owen. Some anatomists, however, struck by the resemblance of the patella to the olecranon, in position and in giving attachment to an extensor muscle similar in appearance to the triceps extensor brachii, have taken a different view; thus, according to Vicq D'Azyr, the tibia corresponds with the ulna, while, according to Bourgery, Cruveilhier, and Martins, its upper end corresponds with the ulna and its lower end with the radius. This latter hypothesis must be regarded as

particularly unhappy, as it is difficult to conceive how any substantial homology, or a resemblance other than fanciful, can be traced by imagining half of a bone to correspond with one structure, and the other half with a structure totally different. Equally artificial is the proposition of Vicq D'Azyr to compare the upper limb of one side with the lower limb of the other side of the body. The assumed correspondence of the olecranon and patella, which has led to those theories, is not borne out by a comparison of the development of the two structures. The patella is formed, distinct from the tibia, as a sesamoid bone in a tendon, while the olecranon is mainly derived from the principal centre of ossification of the ulna, and is formed only in part by the superior epiphysis of that bone. In support of the more probable view, that the ulna corresponds with the fibula, it is to be noticed that in the echidna the head of the fibula is prolonged upwards into a process which much more closely corresponds with the olecranon than does the patella. It may also be observed that in certain mammals, such as the bear or other plantigrades, in which there is a power of partial pronation, the radius crosses the forearm obliquely, and its upper end is brought somewhat in front of the ulna; while in the greater number of mammals, in which there is no power of pronation or supination, the radius is placed entirely to the front and internally, and the ulna is thrown to the outside and behind, in the same manner as the fibula is to the outside of and behind the tibia; and the resemblance between the respective bones in the fore and hind limbs is made the more striking that the radius and tibia are in these animals generally the principal bones, while the ulna and fibula are in many species only partially developed. An examination of the fore limb in a series of animals shows that the articulation of the radius with a separate portion of the humerus external to that with which the ulna articulates is quite exceptional, the most common arrangement being that the ulna forms the posterior and the radius the anterior part of one great sigmoid cavity similar to that formed by the ulna in the human subject. In comparing the humeral with the femoral region it may be well to have regard to the apparent twist inwards which is seen in both femur and humerus, but especially in the latter bone. This appearance of twisting is given to the humerus by the direction of the musculo-spiral groove, and by the obliquity in the direction of all the ridges of the bone. In the femur the twisted appearance is very slight, and is most obvious below and in front of the small trochanter. In the humerus the appearance of twisting is much more marked, and is more especially obvious at the spiral groove. If, while the forearm remains unmoved, the lower end of the humerus were turned outwards a quarter of a circle, so as to undo the twist of the bone, the inner condyle would then overhang the flexor aspect of the forearm, and the outer condyle the extensor aspect, and the flexor and extensor muscles would pass directly downwards from the condyles to their terminations. Assuming this mode of viewing the position of the humerus to be correct, we may proceed to compare the limbs by considering the hand and foot, and also the forearm and leg, as having their flexor surfaces directed towards the mesial plane of the body (the position in which they are developed), while the condyles of the humerus and femur continue to be external and internal in position, and the anterior or flexor surface of the humerus corresponds with the anterior or extensor surface of the femur. From this it follows that one of the propositions maintained by those who regard the tibia and ulna as homologous, viz., that the quadriceps extensor femoris obviously corresponds with the triceps brachialis, must be erroneous, and that the biceps femoris may more justly be viewed as corresponding with the triceps brachialis, while the rectus femoris is homologous with the biceps of the arm, and the vasti and crureus with the brachialis anticus muscle, which in some animals extends up to the neck of the humerus; so also the space between the lips of the linea aspera of the femur (which in most animals is much broader than in man) will correspond with the posterior surface of the humerus below the musculo-spiral groove.

The detailed comparison of the bones of the shoulder and pelvis is beset with many difficulties, and it must therefore suffice here to remark that it requires further investigation than has been brought to bear upon it, and simply to state that while the scapula obviously corresponds with the ilium, the clavicle is generally regarded as corresponding with the os pubis, and the coracoid process (or coracoid bone of birds and reptiles) with the ischium. Humphry, indeed, has put forward the idea that the upper and lower limbs ought to be regarded not as lying in series but as facing one another,—that is to say, as being related to one another symmetrically,

one at the upper and the other at the lower end of the trunk, in the same way that the limbs of opposite sides are arranged symmetrically on either side of the mesial plane. Thus, in the skeleton of a quadruped, the scapula and humerus slope backwards from the shoulder-joint, and the ilium and femur slope forwards from the hip-joint; the prominence of the elbow looks backwards, and that of the knee looks forwards; and hence, according to Humphry, the coracoid and pubis and the clavicle and ischium respectively correspond. It will, however, suggest itself to the reader from the remarks already made, that there are serious difficulties in the way of attributing to those appearances, which are only the result of later development, more than a mere secondary importance. (Copious reference to the literature of this subject is made in the paper by Ch. Martins in the "Annales des Sciences Naturelles, Zoologie," vol. viii. 1857, p. 45. See also Humphry, "On the Limbs of Vertebrate Animals," &c. Cambridge, 1860.)

RELATION OF THE LIMBS TO THE SEGMENTS OF THE TRUNK.

The various anatomists who have written on this subject agree in considering that the limbs, in their extent beyond the shoulder and hip, are radiations from or appendages of one or more segments of the trunk. Opinions, however, are much divided with regard to the nature of the pelvic and shoulder girdles, and, in particular, it has been warmly debated whether or not they are costal arches. Owen holds the opinion that they are costal, and further considers that the scapula and coracoid process form the costal arch of the occipital vertebra, with the free part of the limb as its appendage, while the clavicle is derived from another segment; and that in like manner the ilium and ischium form the costal arch of one segment supporting the lower limb, and that the pubic bone belongs to another. The circumstance which has specially led to the supposition that the upper limb and the occipital bone are connected is, that the shoulder girdle is attached to the skull in most osseous fishes; but it may be objected to this hypothesis that in the higher vertebrata the anterior extremities are developed from a portion of the embryo considerably removed from the skull; and Goodsir fairly argues, from the nervous supply to the limbs, and from the limbs first appearing with the digits arranged in series in the plane of the lateral plates of the embryo, that a limb is not an appendage to a single segment of the trunk, but belongs to several segments. (Owen, "On the Nature of Limbs;" Goodsir, "On the Morphological Constitution of Limbs," Edinb. New. Phil. Journ., Jan., 1857.)

THE SKELETON ADAPTED TO THE ERECT POSTURE.

Throughout the whole of the human frame numerous peculiarities in the form and proportion of parts exist, connected with the assumption of the erect posture. The most striking of the structural peculiarities related to this circumstance are seen in the skeleton, and they are equally apparent in the head, trunk, and limbs. The body of man, unlike that of animals, is, for the purposes of station and progression, balanced on one or both pelvic limbs, which are extended to a straight line at the knee-joint. The lower limb is remarkable for its length and strength. The foot of man alone has an arched instep, and it likewise presents a great breadth of sole. The great toe is distinguished by its large development, and especially from that of the quadrumana, by its want of opposability, being formed not for grasping but for supporting the weight of the body and giving spring to the step. The femur is greatly elongated, its length exceeding considerably that of the tibia. This length of femur is not only requisite in order to give a sufficient extent of stride, but also to enable the body to be balanced in different degrees and varieties of stooping. Thus, for example, in a crouching attitude, with the feet placed side by side, it is necessary in order to balance the fore part of the body that the pelvis should be brought back behind the perpendicular rising from the balls of the toes on which the weight is rested: and in order to accomplish this, if there be a long tibia directed forwards from the ankle, there must be a femur of still greater length directed backwards from the knee. The breadth of the pelvis, in like manner, in lateral movements of the body, enables the balance to be more easily maintained by compensating inclinations of different parts to opposite sides of the base of support, and the long neck of the femur gives an advantageous insertion to the muscles by which the balance of the body on the thigh is principally preserved (viz., the adductor and gluteal muscles), placing them more nearly at

right angles to the bones on which they act. The os innominatum is principally distinguished from the same bone in animals by the breadth of the iliac portion, which gives support to the viscera and attachment to the greatly developed gluteal muscles, by the shortness and strength of the pillar of bone extending from the auricular surface to the acetabulum, and by the marked nature of the angle which the pubic part forms with the iliac, as it passes inwards from the acetabulum to the symphysis, and thus completes the peculiarly broad pelvis. The strong and expanded sacrum supports the spinal column, while the short coccyx is bent forwards and aids in forming the floor of the pelvic cavity. The spinal column, by its pyramidal form, is fitted to sustain the weight which bears down upon its lower part, and by means of its different curvatures gives elasticity and strength, and allows considerable range of motion to the trunk without removal of the centre of gravity from within its base. The thorax is so formed as to bring the weight of its contents very much over and to the sides of the bodies of the vertebræ rather than in front. Thus, the thorax is broad from side to side, and compressed from before backwards; the transverse processes and proximal parts of the ribs are inclined backwards, so as to enlarge the chest behind the transverse plane of the bodies of the vertebræ, and the axis of the cavity is directed upwards and backwards, so that its contents may thus be supported on the column in the erect posture. The upper limbs are also thrown outwards and backwards by the long clavicles which support them and form the fulcra of their free movements. The blades of the scapulæ are thus made to lie more nearly in one transverse plane, with the glenoid fossæ looking outwards, a position manifestly unsuited to the support of the weight of the body on the limb. In those animals which habitually use their fore limbs for support, the glenoid fossæ look downwards, and rest on the humeri; but if the human body be placed so as to be rested on the hands, the glenoid cavity lies on the inside of the head of the humerus, and the scapula is supported upon the humerus by the acromion process. While stability and strength have been provided in the lower limb, mobility and lightness have been secured in the upper. This is apparent on comparison of the shoulder, elbow, and wrist, with the hip, knee, and ankle. In the hand also, the movable phalanges are as long as the carpal and metacarpal bones taken together, whereas in the foot they are not a third of the length of the tarsal and metatarsal bones. The skull of man differs from that of animals in being nearly balanced on the vertebral column, the condyles of the occipital bone being brought forwards towards the middle of the base, by the comparative shortness of that part of the skull which lies in front of the foramen magnum, and the projection backwards of that which lies behind it. In animals the skull hangs forwards, as it were, from the extremity of the column, and is sustained by an elastic substance (ligamentum nuchæ), which is attached on the one hand to the spinous processes of the vertebræ, and on the other to the occipital protuberance.

Section II.—ARTHROLOGY.

MODES OF ARTICULATION.

The name of articulation, synonymous with joint, is given in descriptive anatomy to the connection subsisting in the recent skeleton between any of its denser component parts, whether bones or cartilages. In all instances, excepting the bones of the head, which are so closely set together in the sutures as to have no more than the fibrous periosteum between them, some softer intervening substance lies between the bones, uniting them together, or clothing the surfaces which are opposed; but the manner in which the several pieces of the skeleton are thus connected, or the modes of articulation, vary to a great degree both in the form and nature of the uniting substances and in the extent of motion which they allow between the bones. In some instances, as in that of the cranial bones already referred to, the closeness of the apposition, the unevenness of the fitting surfaces or edges, and the small amount and dense nature of the

intervening substance, are such as to admit of little or no perceptible motion. In other instances the extremities of the bones are placed at such a distance, and the intervening substance (ligament or cartilage) possesses so much of a yielding quality, that bending or other motions may take place, even while the bones are thus mediately but continuously united. But in the greater number of the connections between the bones, and in those which may be regarded as more properly deserving the name of joints, the apposed surfaces of bone are not united either directly or mediately with each other, but are free by solution of continuity, and are covered with plates of smooth cartilage, the surfaces of which fit accurately together, and the bones are held together by ligamentous structures placed in the vicinity of the joints. In such articulations the bones are capable of gliding or moving upon each other in various extent and directions, according to the shape of the opposed cartilaginous surfaces, and the form and attachments of the ligamentous and other bands which unite them. It is upon distinctions such as those now adverted to that the various kinds of joints or articulations have been brought under the three classes of SYNARTHROSIS, AMPHIARTHROSIS, and DIARTHROSIS.

Synarthrosis means direct or immediate union, and comprehends the joints with little or no motion. It is found chiefly in various forms of suture by which the bones of the head, excepting the lower jaw, are united. The *suture*, properly so called, is *serrated* or *dentated* when the contiguous margins of the bones are subdivided or broken up into projecting points and recesses by which they fit very closely to one another, as in the borders of most of the tabular bones of the cranium. The *squamous* or scaly suture is that in which, as in the union of the temporal with the parietal bone, the edges are thinned and bevelled, so that one overlaps the other to a considerable extent.

The term *harmonia* has been employed to denote simple apposition of comparatively smooth surfaces or edges, as in the case of the two superior maxillary bones; and the term *schindylesis* has been used to express that kind of union in which one bone is received into a groove in another, as occurs between the rostrum of the sphenoid bone and the vomer. The impaction of the roots of the teeth in their sockets has likewise been reckoned among the articulations, though with doubtful propriety, and has been designated by the term *gomphosis*.

Amphiarthrosis means the mixed articulation, or that in which there is mediate union by some intervening substance, with partial mobility. The articulations between the bodies of the vertebræ, that between the two ossa pubis at the symphysis, and that between the two first pieces of the sternum, may be taken as examples of this mode of connection. Some of the joints of this kind pass on the one hand into synarthrosis, and on the other into diarthrosis.

Diarthrosis includes the complete joints with separate surfaces of the bones and synovial cavities, and is attended with considerable yet varying degrees of mobility. In this form of joint, plates of cartilage cover the articular parts of the bones and present within the joint free surfaces of remarkable smoothness, and these surfaces are further lubricated by the synovial fluid secreted from the delicate membrane which lines the fibrous coverings and all other parts of the articulating cavity except the cartilage. This membrane is continuous with the margin of the articular cartilages, and along with the cartilages completely encloses the joint cavity. The bones are further held together by fibrous tissue in the various forms of ligaments, such as membranous capsules, flat bands, or rounded cords. These ligaments, it is true,

are not so tight as to maintain the bones in close contact in all positions of the joint, but are rather tightened in some positions and relaxed in others, so that they may be looked upon chiefly as controllers of the motions. The bones are likewise held together in diarthrodial joints, by atmospheric pressure, and by the surrounding muscles.

MOTIONS OF THE BONES IN THE JOINTS.

The various movements of the bones on one another in the joints are distinguished by different terms according to their directions, viz., angular movement, circumduction, rotation, and shifting; but it is proper to remark that although different kinds of motion, answering to these several terms, may readily be recognised, yet there are few of the motions which occur in the joints which are of one sort only, but rather several kinds of movement are frequently combined in one, and they also run into one another in great variety.

Angular movement, or *opposition*, is movement in such a manner as to increase or diminish the angle between two bones, so that they shall lie more or less nearly in a straight line. The different kinds of angular movement are designated by different terms according to the directions in which they take place with reference to the limb or body: thus, *flexion* and *extension* indicate angular movements, which have the effect of bending or straightening parts upon one another or upon the trunk of the body; *adduction* and *abduction* indicate angular movement to and from the mesial plane of the body, or, when fingers and toes are referred to, these terms may be used to denote movement to and from the middle line of the hand or foot.

Circumduction is the movement performed when the shaft of a long bone or a part of a limb describes a cone, the apex of which is placed in the joint at or near one extremity of the bone, while the sides and base of the cone are described by the rest of the moving part.

Rotation signifies movement of a bone round its axis without any great change of situation.

Shifting is a term which may be applied to that kind of movement in which the surfaces of adjacent bones are displaced without any accompanying angular or rotatory motion, as in the sliding of flat surfaces over each other, such as in some of the carpal and tarsal articulations, or in the movement of advance and retreat of the lower jaw.

The term *ginglymus* is used to distinguish a hinge joint, or one which admits only of flexion and extension. *Enarthrosis* (Cruveilhier) is the ball-and-socket form of joint, like the shoulder and hip, allowing motion in every direction. *Arthrodia* is employed by Winslow and Cruveilhier to signify a joint admitting of very little movement.

In the preceding paragraphs attention has been called only to the directions of the movements of the parts united in the joints, but the movements of opposed articular surfaces relatively one to another are likewise worthy of notice.

In the movements of the joints, when occurring between separate opposed surfaces, there is generally more or less of a *gliding* motion of one surface on the other; but it is to be observed that in some joints a small amount of motion may be produced without gliding, by the alternate contact and separation of different parts of the opposed surfaces, to which the name of *coaptation* (Goodsir) has been applied; and that in other joints the articular surface of one bone may travel over that of another, so as to bring different parts of the surfaces successively into contact, in the manner of a wheel rolling on the ground, with or without this change of place being accompanied by gliding motion.

In the various joints provided with synovial cavities, the cartilaginous surface of the bones are so formed as usually to be in close apposition or contact; but it would

appear that in certain positions they are not entirely so, and it can scarcely be doubted that when the surfaces are separated to any extent, doublings of the synovial membrane, or fatty processes connected with it and placed in the immediate vicinity of the joint, contribute to fill up the vacuity. There are even instances in which it would appear that the separation of the surfaces must be considerable, as in the case of the patella, more especially in complete extension of the knee.

ARTICULATIONS OF THE TRUNK AND HEAD.

ARTICULATIONS OF THE VERTEBRAL COLUMN.

The movable vertebræ are connected together by elastic discs interposed between the bodies; by synovial joints between the articulating processes; and by ligaments.

Fig. 107.

Fig. 107.—A Lumbar Vertebra, seen from above, with part of the Intervertebral Disc adhering to the body. ½

1, 1, the concentric arrangement of the fibrous laminæ; 2, the central soft cartilaginous or gelatinous substance.

The *intervertebral discs* are plates of composite structure placed one between the bodies of each pair of vertebræ from the axis to the base of the sacrum. Each is composed of a laminar part externally, and of a pulpy substance in the centre.

The laminar part forms more than half of the mass, and consists of concentric laminæ of fibro-cartilage and fibrous tissue alternating one with another. These laminæ are not quite vertical, for if a vertical section of a disc be made, a certain number of the layers nearest to the circumference of the disc will be seen bulging outwards, while others situated more deeply and less closely compacted together are convex towards the centre; and

Fig. 108.

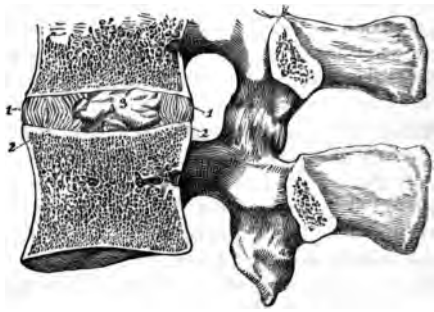


Fig. 108.—Vertical Antero-Posterior Section through two Lumbar Vertebræ, showing the arrangement of the Intervertebral Disc. ⅔

1, 1, the fibrous oblique bands, which are curved outwards; 2, those which are curved inwards; 3, the central soft cartilaginous or gelatinous substance: the capsule of the joint between the articular processes is represented.

when the spine is bent in any direction, the curves of the different layers are augmented on the side towards which the column is inclined. The individual layers consist chiefly of fibres extending obliquely between the

vertebræ and firmly attached to both; the direction of the obliquity being reversed in each successive layer, in one stretching downwards from right to left, and in the next from left to right. Some of the fibres also are nearly horizontal. The central part of the fibro-cartilage is a pulpy and elastic material which, when the pressure which confines it is taken off by cutting through the intervertebral substance, rises up so as to assume a conical form. It is then seen to be of a lobate structure, and, examined under the microscope, exhibits a finely fibrous and homogeneous matrix, with numerous spherical and elliptical cells, some of them resembling cartilage-corpuscles, others larger and of various appearance.

It is now generally admitted that the pulp of the intervertebral disc is a persistent part of the chorda dorsalis; homologous, therefore, with those larger vestiges of the chorda dorsalis which occupy the biconical cavities between the bodies of the vertebræ in fishes. According to Luschka, there is present in each disc a synovial cavity, and the lobes of the pulp are synovial villi, similar to those which are to be found in the knee and shoulder joints, but of larger size, and occupying the whole cavity; and it is worthy of notice that in like manner secondary cavities, developed within the chorda dorsalis, are found in the intervertebral substance in many fishes. The same writer describes small synovial sacs, in the cervical region, in those parts of the discs which are attached to the lateral elevations of the bodies of the vertebræ. Occasionally the pulp of the discs projects backwards, through the surrounding laminæ, so as to form a slight projection into the spinal canal. (Luschka, "Die Halbgelenke des Menschlichen Körper's," Berlin, 1858, p. 84.)

A thin cartilaginous layer, incomplete towards the circumference, covers the surfaces of the vertebræ and gives attachment to the discs. Excluding from consideration the first two vertebræ, between which it does not exist, the intervertebral material forms in length about a fourth of the movable part of the column. The dorsal part of the column has, comparatively with the length, a much smaller proportion than the cervical or lumbar parts.

The discs in the cervical and lumbar regions are thicker in front than behind, and it has been determined that the convexity of those portions of the column is due to them much more than to the bodies of the vertebræ, while the arching of the dorsal portion, on the contrary, is rather owing to the shape of the bones. (W. and E. Weber, "Mechanik der menschl. Gehwerkzeuge," p. 90, et seq., Göttingen, 1836.)

The *anterior common ligament* is a strong band of fibres, which is placed on the front of the bodies of the vertebræ, and reaches from the atlas to the first bone of the sacrum, becoming broader as it descends. It consists of longitudinal fibres which are dense, firm, and well marked. The superficial fibres extend from a given vertebra to the fourth or fifth below it; the fibres subjacent to these pass over the bodies of several vertebræ; whilst the deeper ones pass only between adjacent vertebræ. The band is thicker towards the middle of the bodies of the vertebræ than at their margins, or over the intervertebral cartilages; by which means the transverse depressions of the bodies are filled up, and the surface of the column rendered more even. The fibres adhere more closely to the margins of the bones than to the middle of their bodies, and still more closely to the intervertebral cartilages. Upon the sides of the bodies there are some fibres which are thin and scattered, and reach from one bone to another.

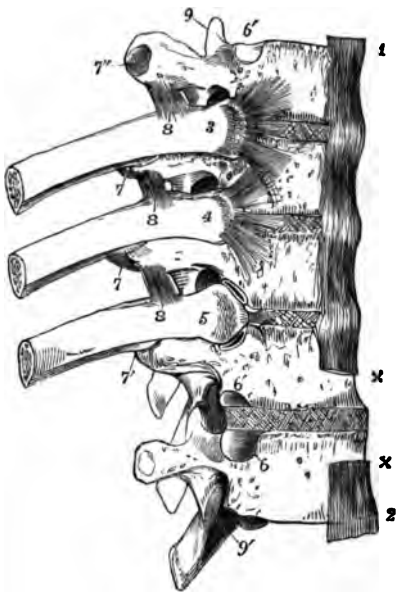
The *posterior common ligament* is situated within the spinal canal, and is attached to the posterior surface of the bodies of the vertebræ; it extends from the occiput to the sacrum. It is smooth, shining, and broader at the

upper than at the lower part of the spine. In the neck it extends quite across the bodies, but in the back and loins it is broader opposite the inter-

Fig. 109.—View of a part of the Vertebral Column, including the 5th, 6th, 7th, 8th, and 9th Dorsal Vertebræ, with a part of the 6th, 7th, and 8th Ribs, from the right side and front. ⅓

The 5th and 9th ribs have been removed so as to show the articular surfaces of the vertebræ corresponding to them; 1 to 2, the anterior common ligament of the bodies of the vertebræ; at × ×, a portion of the ligament is removed so as to expose the intervertebral plate between the 8th and 9th vertebræ, in which the diagonal fibres of the external ligamentous plates are represented. (The further description of this figure will be found at p. 129.)

Fig. 109.



vertebral cartilages than at the middle bodies, so that its margins present a series of points or dentations with intervening concave spaces. It adheres firmly to the fibro-cartilages and to the contiguous margins of the bodies of the vertebræ, but it is separated from the middle of the bodies by the transverse parts of the large venous plexus, which is in contact with the bones. Between the ligament and the prolongation of the dura mater which lines the canal, some loose connective tissue is interposed.

Fig. 110.—The Bodies of three Lumbar Vertebræ, seen from behind, with the Posterior Common Ligament. ⅓

The arches have been removed by cutting through the pedicles. The contraction of the posterior common ligament opposite the middle of each body, and its greater width and attachments opposite the intervertebral discs, are represented.

Fig. 110.

The *joints of the articulating processes* present each a synovial cavity surrounded by an irregular fibrous capsule. The fibrous bands of these capsules are longer and looser in the cervical than in the dorsal and lumbar regions.

The *ligamenta subflava* are ligaments consisting of yellow elastic tissue, which connect the laminæ of the vertebræ. Their fibres are nearly vertical, and are attached superiorly to the anterior surface of the lamina, a little above the inferior margin, and inferiorly to the upper margin and part of the posterior surface of the lamina beneath. They are most distinctly seen when the arches are detached from the bodies of the vertebræ, and they are viewed from the front. Posteriorly they appear short, or in the dorsal region are concealed, being overlaid by the prominent inferior margins of the laminæ

and the roots of the spines. Their outer margins are close to the articulating processes; their inner margins lie in contact in the middle line, and in that situation the ligaments are thickest.

Fig. 111.

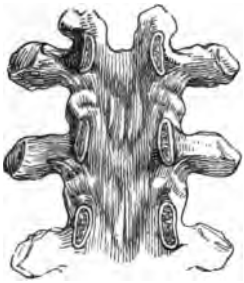


Fig. 111.—The Arches of three Dorsal Vertebræ, seen from before, to show the Ligamenta Subflava. ⅔

The bodies of the vertebræ have been removed by sawing through the pedicles, showing the articular capsules and the ligamenta subflava.

The ligamenta subflava do not exist between the occiput and the atlas, nor between the latter and the axis; common fibrous membrane supplies their place in these two spaces, constituting posterior occipito-atlantal and atlanto-axial ligaments.

The *interspinous ligaments*, thin and rather membranous, have an attachment extending from the root to near the summit of each spinous process, and connect the inferior border of one with the superior border of that next below it. They are best seen in the lumbar region, and are least developed in the neck.

The *supraspinous ligaments* consist of small compressed bundles of longitudinal fibres, which connect the summits of the

Fig. 112.

Fig. 112.—Antero-Posterior Vertical Section of the upper part of the Vertebral Column, and part of the Occipital Bone, showing the Articulations (after Arnold).

1, 1, anterior common ligament of the bodies of the vertebræ; 1′, anterior atlanto-occipital ligament; 2, from this figure upwards the posterior common ligament of the bodies; 2′, the continuation of the preceding and the apparatus ligamentosus lying on the basilar process of the occipital bone; 3, 3, 3, these figures are placed on the inside of the arches of the 2nd and 7th cervical and 6th dorsal vertebræ; the ligamenta subflava are to be seen stretching between the laminæ; 4, 4, placed upon two of the interspinous ligaments; 4′, divided edge of the occipital bone behind the foramen magnum, and below it, the posterior occipito-atlantal ligament and ligaments of the arches; 5, 5, supraspinous ligaments; 6, ligamentum nuchæ; ×, its upper extremity at the occipital tuberosity; × ×, its lower extremity terminating in the supraspinous ligaments of the upper dorsal vertebræ.

spinous processes, and form a continuous chain from the seventh cervical vertebra to the spine of the sacrum. The posterior fibres pass down from a given vertebra to the third or fourth

below it; those more deeply seated reach only from one to the next, or the second below it.

The *ligamentum nuchæ* is the continuation upwards of the supraspinous ligament. It is, in the human subject, a thin intermuscular septum of elastic and white fibrous tissue, the most superficial part of which extends from the spine of the seventh cervical vertebra to the occipital protuberance, while the deeper fibres, springing from the same origin, pass to the occipital spine, and the spines of the six upper vertebræ. It derives importance as the representative of a strong elastic structure in other animals.

The *intertransverse ligaments* are unimportant bands extending between the transverse processes. In the lumbar region they are membranous, in the dorsal region they are rounded bundles intimately connected with the muscles of the back; and in the neck they are usually reduced to a few irregular fibres, which may in some instances be wanting.

MOVEMENTS.—The movement of flexion and extension of the vertebral column is freely allowed in the cervical and lumbar regions, but in the dorsal is limited by the small amount of intervertebral substance and the imbrication of the laminæ. The greatest bending backwards is permitted in the cervical, the greatest bending forwards in the lumbar region, especially between the fourth and fifth lumbar vertebræ. Movements in other directions are limited chiefly by the articulating processes. In the dorsal region the articulating surfaces of each vertebra lie in the arc of a circle whose centre is in front of the vertebra, and round this centre a considerable degree of rotation is permitted. In the lumbar region, the centre of the circle in which the articular surfaces lie being placed behind, rotation would involve an amount of motion between the bodies of the vertebræ that is impossible; the articulating processes, however, fit sufficiently loosely to permit of lateral flexion, and by combination of this with antero-posterior flexion, some degree of circumduction is produced. The articulating surfaces of the cervical vertebræ, being oblique and placed in nearly the same transverse plane, allow neither pure rotation nor pure lateral flexion. They permit, besides forward and backward motion, only one other, which is rotatory round an oblique axis—the inferior articulating process of one side gliding upwards and forwards on the opposing surface, and that of the other side gliding downwards and backwards, by which a combination of lateral flexion and rotation is obtained. The reader who may wish to pursue more minutely the study of the movements of the joints may consult the work of W. and E. Weber already cited; H. Meyer, "Handbuch der Physiol. Anat.;" and Henke, "Handbuch der Anat. und Mech. der Gelenke," 1864.

ARTICULATIONS OF THE ATLAS, AXIS, AND OCCIPITAL BONE.

The atlas, axis, and occipital bone are connected by articular surfaces and ligaments, without the presence of intervertebral discs.

Two pairs of synovial articulations surrounded by capsular ligaments connect the lateral masses of the atlas with the superior articular surfaces of the axis and with the condyles of the occipital bone. The capsule of the atlanto-axial joint is strengthened behind by an accessory ligament, directed downwards and inwards to the body of the axis near the base of the odontoid process.

The *transverse ligament of the atlas* is a strong and thick band, which extends across the ring of the atlas, and retains the odontoid process in its place. It is attached on each side to the impression below the inner border of the superior articulating process. It is arched backwards behind the odontoid process, and is broadened out in the middle line. From the middle of its posterior surface a short thin bundle of fibres passes down to be attached to the body of the axis, whilst another passes up to the basilar

process. These form the figure of a cross with the transverse ligament, and serve to bind the occiput to the first two vertebræ; from this arrangement is derived the term *cruciform*, which is sometimes applied to the transverse ligament and its appendages together.

Fig. 113.

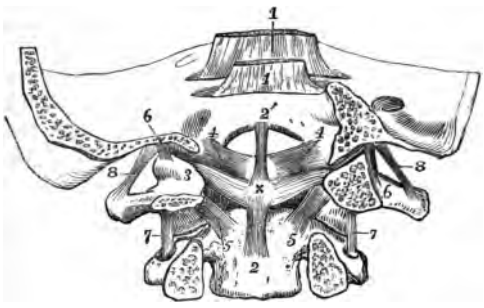


Fig. 113. — TRANSVERSE VERTICAL SECTION OF THE LOWER PART OF THE OCCIPITAL BONE, AND THE TWO UPPER VERTEBRÆ BEHIND THE ARTICULATIONS (after Arnold). ½

1, 1, apparatus ligamentosus and posterior common ligament of the bodies of the vertebræ dissected off the back of the odontoid process, and turned up on the occipital bone; 2, 2′, vertical part, and 3, 3, transverse or principal part of the crucial ligament; ×, neck of the odontoid process; 4, 4, the alar, lateral, check, or occipito-odontoid ligaments; 5, 5, the accessory ligaments of the atlanto-axial capsules, or the lower lateral ligaments of the odontoid process; 6, 6, part of the capsular ligaments of the condyloid articulations; 7, 7, capsular ligaments of the atlanto-axial articulations; 8, 8, intertransverse ligaments between the occiput and atlas.

Two synovial membranes are placed one in front and another behind the odontoid process; the first of these is situated between the process and the anterior arch of the atlas, the other between the process and the transverse ligament.

Fig. 114.

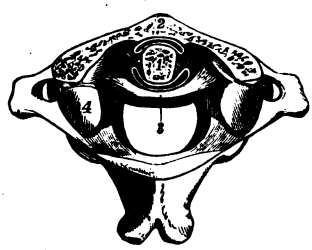


Fig. 114.—VIEW OF THE ARTICULATION OF THE ODONTOID PROCESS OF THE AXIS WITH THE ATLAS, THE UPPER PART OF THE ANTERIOR ARCH OF THE ATLAS AND THE HEAD OF THE ODONTOID PROCESS HAVING BEEN REMOVED BY A HORIZONTAL SECTION. ½

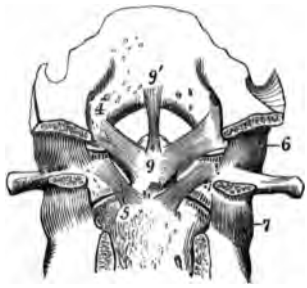
1, cut surface of the odontoid process; 2, cut surface of the anterior arch of the atlas; 3, transverse ligament; between 1 and 2, the anterior synovial cavity; between 1 and 3, the posterior synovial cavity of the articulation; at the sides of the odontoid process, between the anterior and posterior synovial sacs, are seen loose ligamentous fibres; 4, is placed on the back part of the left superior articular process of the atlas: the anterior part of this process, and that of the other side, have been partly removed by the section. For the sake of distinctness, the synovial spaces are represented somewhat wider than natural.

The *odontoid* or *check ligaments* are two thick and very strong bundles of fibres, which extend from the sides of the summit of the odontoid process outwards and a little upwards to be implanted into the rough depression on the inner side of the condyles of the occipital bone, and into a small part of the margin of the foramen magnum. Some of the fibres of the two ligaments are continuous across the middle line.

Fig. 115.—Transverse Section similar to that represented in Fig. 113, with a smaller portion of the Occipital Bone, the Crucial Ligaments being removed.

4, alar or odontoid ligament; 5, accessory atlanto-axial ligament; 6, 7, capsular ligaments of the occipito-atlantal and the atlanto-axial articulations; 9, placed on the head of the odontoid process; 9, 9′, superior or median occipito-odontoid ligament.

Fig. 115.



The *ligamentum suspensorium dentis* or *middle odontoid ligament* consists of fibres which pass directly upwards from the summit of the odontoid process to the margin of the foramen magnum.

Fig. 116.

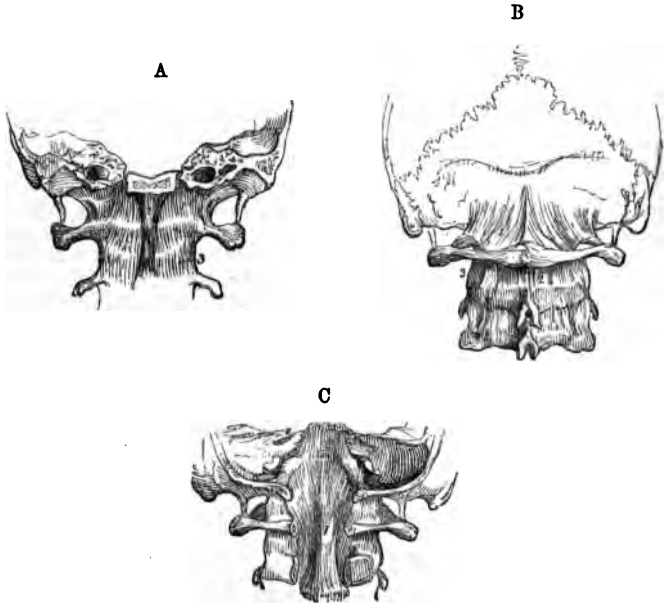


Fig. 116.—The Ligamentous Structures which surround the Articulations of the Occiput and two Upper Vertebræ. ½

A, the lower part of the skull sawn transversely through the basilar process, with the atlas and axis, viewed from before. 1, the anterior occipito-atlantal ligament; 2, the middle thickened part or accessory occipito-atlantal ligament; 3, the anterior atlanto-axial ligament.

B, the lower part of the skull, with three adjacent vertebræ, viewed from behind. 1, the posterior occipito-atlantal ligament; 2, the posterior atlanto-axial ligament.

C, the occipital bone sawn transversely through the foramen magnum, and a part of the arches of the atlas and axis removed posteriorly, so as to show the thickened prolongation of the posterior common ligament of the bodies of the vertebræ with the apparatus ligamentosus.

The *occipito-axial* ligament, sometimes called *apparatus ligamentosus*, is placed beneath the upper part of the posterior common ligament, and covers the crucial and odontoid ligaments. It is a broad band attached above in the basilar groove, and below to the body of the axis.

The *anterior occipito-atlantal ligament* extends from the anterior border of the occipital foramen, between the condyles, to the margin of the anterior arch of the atlas. It is thin, broad, and membranous; but in the median line it is strengthened by an *accessory* ligament, thick and round, placed in front of it, which is sometimes described as the commencement of the anterior common ligament.

The *anterior atlanto-axial ligament*, likewise thin and membranous, except in the middle, where it is thickened, extends from the border of the anterior arch of the atlas to the body of the axis.

The *posterior occipito-atlantal ligament*, thin and membranous, is attached superiorly to all that part of the margin of the occipital foramen which is behind the condyles, and inferiorly to the adjacent border of the arch of the atlas. It is partly blended with the dura mater.

The *posterior atlanto-axial ligament*, similar to the preceding, connects the neural arch of the atlas with that of the axis, in the absence of ligamentum subflavum.

MOVEMENTS.—The atlanto-axial articulation is so constructed that the head, together with the atlas, is rotated on the axis; the odontoid process serving as a pivot. The rotation is limited by the check ligaments. The atlanto-occipital articulation takes no part in rotation, but allows the head to be freely raised or depressed upon the vertebral column. When the atlas is placed symmetrically over the axis, it is seen that the opposing articular surfaces, instead of fitting one to the other, come very slightly into contact, the surface of the axis being inclined too little outwards, and presenting an antero-posterior convexity, to which there is no corresponding concavity presented by the atlas; but a slight rotation brings the bones into a stable position, in which the anterior half of one articular surface of the axis and the posterior half of the other are laid closely against the atlas. It will also be found that a certain amount of oblique motion between the atlas and occipital bone is permitted, by which the anterior half of one condyle and the posterior part of the other may be rested together on the atlas, and that that is the position of greatest stability. This oblique position is that into which the bones are brought when there is any lateral curving of the column, as is the case in the most natural and easy attitudes.

ARTICULATIONS OF THE RIBS.

The articulations of the ribs may be divided into three sets, connecting them with the bodies of the vertebræ, with the transverse processes, and with the sternum.

The *costo-vertebral articulation* unites the head of the rib, in most instances, with the bodies of two vertebræ by two distinct synovial joints, supported by ligaments as follows:—

The *anterior costo-vertebral, costo-central*, or *stellate ligament* is divided into three bundles, of which the middle one passes horizontally forwards upon the corresponding intervertebral fibro-cartilage, whilst the superior ascends to the body of the vertebra above it, and the inferior descends to that below. In the first, eleventh, and twelfth ribs, this ligament is inserted into only one vertebral body, and into no fibro-cartilage.

The *inter-articular ligament* is a thin and short band of fibres, which passes transversely from the ridge separating the two articular surfaces on

the head of the rib to the intervertebral substance, and divides the articulation into two parts, each lined by a separate synovial membrane. The

Fig. 117.

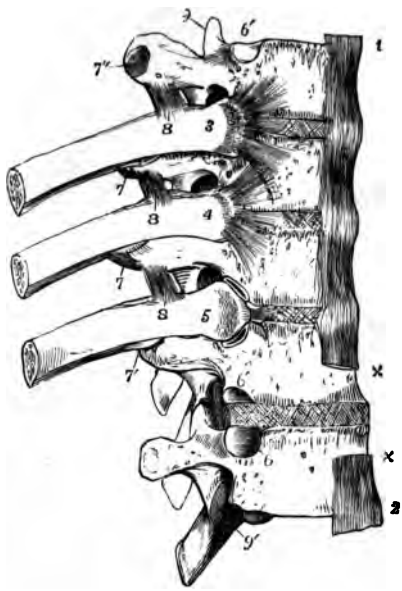


Fig. 117.—View of a part of the Vertebral Column, including the 5th, 6th, 7th, 8th, and 9th Dorsal Vertebræ, with a part of the 6th, 7th, and 8th Ribs, from the right side and front. ½

The 5th and 9th ribs have been removed so as to show the articular surfaces of the vertebræ corresponding to them; 1 to 2, the anterior common ligament of the bodies of the vertebræ; at × ×, a portion of the ligament is removed, so as to expose the intervertebral plate between the 8th and 9th vertebræ, in which the diagonal fibres of the outermost ligamentous plates are represented; 3 and 4, the heads of the 6th and 7th ribs, from which the stellate or anterior costo-central ligaments are seen spreading over the two adjacent vertebral bodies and intervertebral substance; 5, the head of the 8th rib, from which the stellate ligament has been removed, so as to expose the upper and lower synovial cavities, and between them the intervertebral or deep costo-central ligament; 6, lower, and 6′, upper facet of the costo-central articulation; 7, posterior costo-transverse ligament; 7′, the costo-transverse synovial cavity; 7″, the costo-transverse articular facet of the 5th vertebra; 8, the anterior or superior costo-transverse ligament; 9, superior articular process of the 5th vertebra; 9′, inferior of the 9th.

ligament does not exist in the articulations of the first, eleventh, or twelfth ribs, in consequence of those ribs being each attached to only one vertebral body by a single synovial joint.

Fig. 118.

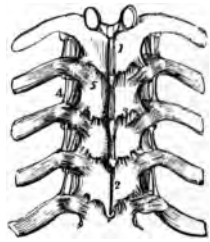


Fig. 118.—Five Dorsal Vertebræ, with portions of the corresponding Ribs. ¼

1 and 2 are placed on the laminæ of the vertebræ, close to the interspinous ligaments; 3, one of the ligamenta subflava, which are only in part seen, being covered to some extent by the laminæ of the vertebræ; 4, anterior costo-transverse ligament; 5, posterior costo-transverse ligament.

The costo-transverse articulation unites the tubercle and neck of the rib to the corresponding transverse process by a synovial joint and ligaments, and by a longer ligament to the transverse process above.

The *posterior costo-transverse ligament* is a distinct band extending outwards from the posterior part of the summit of the transverse process to the rough external part of the tubercle of the rib.

The *middle* or *inter-osseous costo-transverse ligament*, or *ligamentum colli costæ*, consists of a series of very short parallel fibres, which unite the neck of the rib to the anterior surface of the contiguous transverse process. These fibres are seen on removing by horizontal section a portion of the rib and transverse process, and forcibly drawing the one from the other.

Fig. 119.

Fig. 119.—HORIZONTAL SECTION OF A DORSAL VERTEBRA, WITH THE ADJACENT PORTIONS OF TWO RIBS. ⅔

1, the rib; 2, transverse process; 3, anterior costo-central ligament; 5, posterior costo-transverse ligament; 6, interosseous or middle costo-transverse ligament.

The *anterior, superior*, or *long costo-transverse ligament* consists of fasciculi of fibres, passing from the neck of the rib obliquely upwards and outwards to the lower margin of the transverse process next above it. It does not exist in the articulation of the first rib.

There are no synovial joints, but only posterior costo-transverse ligaments, between the two lowest ribs and the transverse processes.

The COSTO-STERNAL ARTICULATIONS, situated between the anterior angular extremities of the cartilages of the sternal ribs, and the corresponding fossæ in the margins of the sternum, consist of small synovial capsules covered and supported by anterior, posterior, upper and lower ligaments; the anterior ligamentous fibres are thin, scattered, and radiated, passing from the extremity of the cartilage to the anterior surface of the sternum, where they interlace with those of the opposite side, and are blended with the aponeurosis of the pectoralis major muscle; the posterior fibres are similarly disposed, but not so thick or numerous, and connect the thoracic surfaces of the same parts; the upper and lower ligamentous fibres are inconsiderable, and are placed above and below the joint; the *synovial membranes* are interposed between the end of the cartilage of each true rib (excepting the first) and the sternum, and may best be demonstrated by slicing off a little of the anterior surface of the sternum and cartilage; that of the seventh is single; the others are usually divided into an upper and lower cavity, between which interarticular fibres are attached to the end of the cartilage and to the sternum. The cartilage of the first rib is directly united to the sternum.

A thin fasciculus of fibres connecting the cartilage of the seventh rib, and sometimes likewise that of the sixth, with the xiphoid cartilage, is called the *costo-xiphoid ligament.*

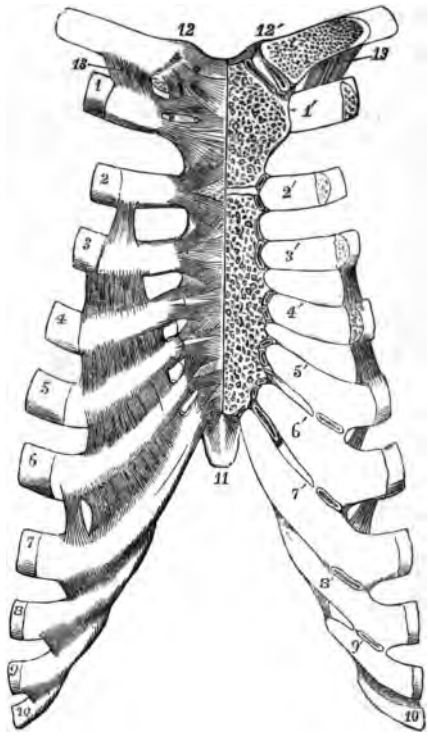
Articulation of the cartilages one with another.—The contiguous edges of the cartilages of some of the ribs, viz., from the sixth to the ninth, have a part of their adjacent borders smoothed into articular surfaces, which are lined by synovial membranes, and are held in connection by ligamentous fibres. Some of the articular surfaces are occasionally found to be wanting.

Connection of the ribs with their cartilages.—The external extremities of the cartilages are fixed into the oval depressions on the ends of the ribs, and the union receives support from the periosteum.

Fig. 120.—Articulations of the Sternum, Clavicle and Ribs, as seen from before (after Arnold). ⅛

On the right of the middle line the anterior ligaments are shown; on the left side, the front parts of the clavicle, sternum and costal cartilages have been removed so as to display the articular cavities. 1 to 10, the anterior extremities of the ribs from the first to the tenth inclusive, on the right side; 1′ to 10′, the costal cartilages of the left side from the first to the tenth inclusive; at 1′, the direct union of the first costal cartilage with the sternum is shown; at the sternal ends of the cartilages marked 2′ to 6′, the small double synovial cavities are shown opened; between the costal cartilages on the right side, ligamentous bands are shown stretching over the intercostal spaces; and on the left side, by a section, small synovial cavities are shown between the adjacent edges of the intercostal cartilages from the 5th to the 9th; on the front of the right half of the sternum the radiating anterior costo-sternal ligaments are shown; 11, the ensiform process; 12, 12′, the interclavicular ligament; and below 12, the anterior sterno-clavicular ligament; below 12′, the sterno-clavicular articulation is opened, showing the interarticular fibro-cartilage and double synovial cavity; 13, the costo-clavicular or rhomboid ligament.

Fig. 120.



Ligaments of the sternum.—The manubrium, body and xiphoid process of the sternum, so long as they are not united by bone, are connected by intervening cartilage, and by anterior and posterior ligaments; and the whole sternum is much strengthened by thick periosteum and by the crossing and longitudinal bands of the costo-sternal ligaments already mentioned.

Movements of the Ribs.—Each rib is capable of a certain amount of elevation and depression at its vertebral articulation, and of rotation on an axis passing between its vertebral and sternal ends. The heads of the ribs are, however, bound down by the inter-articular ligaments so tightly as to prevent any gliding motion at the attachments of those ligaments, which may therefore be regarded as the fixed points round which the ribs are moved. When the vertebral column is bent forwards, the ribs are depressed; and in the same manner, when the column is rotated, the ribs of that side towards which the upper part of the trunk is turned are raised, and those of the other side correspondingly depressed. The movement of the tubercle of the rib on the transverse process is of a gliding description, in the circumference of a circle of which the head of the rib is the centre; and as the plane in which the opposed surfaces of the costo-transverse articulation in most instances lies looks upwards and backwards, the ribs are moved backwards as well as upwards in inspiration, and forwards and downwards in expiration. The combined movements of the thoracic walls in respiration will be described along with the actions of the intercostal

muscles. It is sufficient at present to state that the elevation and rotation of the ribs in inspiration are the main causes of the antero-posterior and transverse enlargement of the chest. The angular movement is greatest in the upper and least in the lowest ribs.

TEMPORO-MAXILLARY ARTICULATION.

The lower jaw articulates by its condyle on each side with the smooth surface of the temporal bone, extending over the part of the glenoid fossa

Fig. 121.

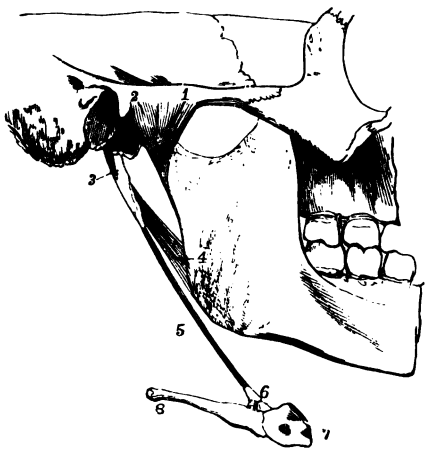


Fig. 121.—A PORTION OF THE SKULL AND LOWER JAW WITH HALF THE HYOID BONE, SEEN FROM THE RIGHT AND OUTER SIDE (after Arnold). ½

1, the external lateral ligament of the tempero-maxillary articulation; 2, a part of the capsular ligament of the joint; 3, styloid process; 4, stylo-maxillary ligament; 5, stylo-hyoid ligament; 6, the lesser cornu of the hyoid bone with some short ligaments attaching it to the body and great cornu; 7, the body; 8, the extremity of the great cornu.

in front of the Glaserian fissure and the anterior root of the zygoma. The joint is divided by an interarticular fibro-cartilage into an upper and lower synovial cavity.

The *external lateral ligament* is a short fasciculus of fibres, attached

Fig. 122.

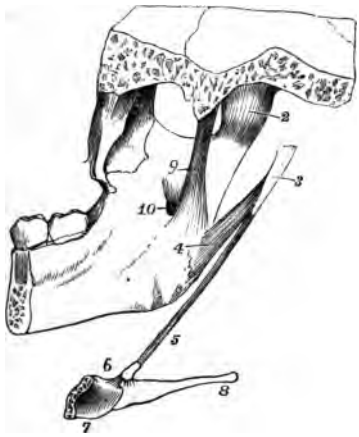


Fig. 122.—A PORTION OF THE SKULL AND LOWER JAW WITH HALF THE HYOID BONE, SEEN FROM THE INSIDE. ½

The indications where marked are the same as in Fig. 121; the styloid process, 3, is detached from the skull; the body of the hyoid bone, 7, is represented as cut through in the middle, so that the posterior and inner surface of the right half of the bone is seen; 9, the internal lateral ligament of the tempero-maxillary joint; 10, the upper opening of the inferior maxillary canal.

above to the external surface and the tubercle of the zygoma; and below, to the external surface and posterior border of the neck of the lower jaw, its fibres being directed downwards and backwards. Thin and short additional ligamentous fibres cover the synovial membrane and form an irregular capsule round the joint.

The *internal lateral ligament*, thin, loose, and elongated, lies at some distance from the joint. It extends from the spinous process of the sphenoid bone downwards and a little forwards, to be attached to the inner border of the dental foramen in the inferior maxillary bone. Between it and the lower jaw are placed the external pterygoid muscle, the internal maxillary artery, and the inferior dental nerve. It has no immediate connection with the joint, and by some anatomists is not recognised as a ligament.

The *inter-articular fibro-cartilage* is a thin plate, placed between the articular surfaces of the bones. It is of an oval form, broadest transversely, thickest posteriorly, and thinnest at its centre, where it is sometimes perforated. The inferior surface, which is in contact with the condyle, is concave; the superior is concavo-convex from before backwards, conforming with the articular surface of the temporal bone. Its circumference is connected at the outside with the external lateral ligament, and anteriorly with the external pterygoid muscle.

Fig. 123.

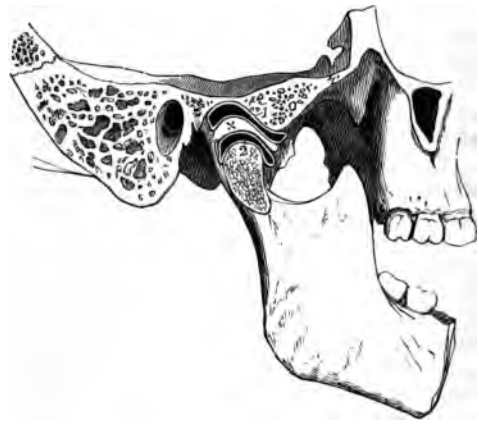


Fig. 123.—Antero-Posterior Section of the Temporo-Maxillary Articulation of the right side. ½

1, is placed close to the articular eminence, and points to the superior synovial cavity of the joint; 2, is placed close to the articular surface of the head of the lower jaw, and points to the inferior synovial cavity of the joint; ×, is placed on the thicker posterior portion of the inter-articular fibro-cartilage.

Synovial Membranes.—The synovial membrane which lies between the inter-articular fibro-cartilage and the glenoid cavity is larger and looser than that which is interposed between the fibro-cartilage and the condyle of the jaw. When the fibro-cartilage is perforated the upper and lower synovial cavities necessarily communicate one with the other.

The *stylo-maxillary ligament* is the name given to a strong or thickened band of fibres connected with the cervical fascia extending from near the point of the styloid process to the posterior border of the ramus of the jaw, where it is inserted between the masseter and internal pterygoid muscles. It separates the parotid from the submaxillary gland.

It may be proper also to mention in this place the *stylo-hyoid ligament*, a thin fibrous cord, which extends from the point of the styloid process to the lesser cornu of the hyoid bone, and serves to suspend that bone from the styloid process. A considerable portion of the stylo-hyoid ligament is sometimes converted into bone in the human subject, and in animals it is naturally osseous, and constitutes the epi-hyal bone.

Movements.—The jaw is capable of movements of elevation and depression, of some degree of lateral displacement, and of protraction and retraction; but it is to be observed that when the jaw is depressed, as in opening the mouth, the condyle advances from the glenoid cavity so as to be placed on the articular eminence in front

of it. The movements which take place in the superior and inferior compartments of the joint are of different kinds. In the upper the fibro-cartilage glides backwards and forwards on the temporal bone; in the lower compartment the condyle rotates on a transverse axis against the fibro-cartilage. In opening the mouth the two movements are combined: the jaw and fibro-cartilage together move forwards and rest on the convex root of the zygoma, while at the same time the condyle revolves on the fibro-cartilage. When the lower incisors are protruded beyond those of the upper jaw, the movement is confined chiefly to the upper articulation; and when the same movement is alternately performed in the joints of opposite sides a horizontal or grinding motion is produced. The fibres of the external lateral ligament remain tight both in shutting and opening the mouth, and it is owing to their direction that in opening the mouth the condyle is driven forwards.

ARTICULATIONS OF THE UPPER LIMB.

THE SCAPULO-CLAVICULAR ARCH.

The supporting arch of the upper limb has only one point of attachment to the trunk, namely, that at the sterno-clavicular articulation; the scapula being connected with the trunk only by muscles.

The clavicle articulates at its inner end with the first bone of the sternum, and is connected by ligaments to its fellow of the opposite side and to the first rib. At its outer end it is united to the scapula.

Sterno-Clavicular Articulation.—The articular surface of the inner end of the clavicle is considerably larger than the opposing surface of the sternum. Between the two bones an inter-articular fibro-cartilage is interposed.

The *anterior sterno-clavicular ligament*, broad and consisting of parallel fibres, passes from the inner extremity of the clavicle in front downwards and inwards, upon the anterior surface of the sternum.

The *posterior sterno-clavicular ligament*, lying on the thoracic aspect of the joint, is of similar conformation with the anterior ligament, but is not so broad or strongly marked.

The *inter-articular fibro-cartilage*, nearly circular in its form, and thicker above and at the border than at the centre, is interposed between the articulating surfaces of the sternum and clavicle. Towards its upper part it is attached to the inner and upper part of the clavicle, and at its lower edge to the cartilage of the first rib. In the latter situation it is thin and somewhat prolonged, so that the inferior border of the clavicle rests upon it.

Synovial membranes.—In this articulation, as in that of the lower jaw, there are two cavities lined by synovial membrane, one on each side of the inter-articular fibro-cartilage.

The *inter-clavicular ligament* is a dense fasciculus of fibres, between the contiguous extremities of the clavicles. It dips downwards in the middle, and is connected with the upper margin of the sternum, filling up a part of its interclavicular notch.

The *costo-clavicular ligament* (ligamentum rhomboides,—Weitbrecht) does not properly form part of the sterno-clavicular articulation; yet it contributes materially to retain the clavicle in its situation. It is attached inferiorly to the cartilage of the first rib near its sternal end, and passes obliquely backwards and upwards, to be fixed to a rough depression at the under surface of the clavicle near the sternal end.

Scapulo-Clavicular Connections.—At its outer end the clavicle articulates with the acromion, and is connected by ligamentous fibres with the coracoid process.

The *acromio-clavicular articulation* is a synovial joint uniting the outer extremity of the clavicle with the inner edge of the acromion. It is sup-

ported above by a thick and broad *superior ligament*, and below by an *inferior ligament* which is not so strong. An *inter-articular fibro-cartilage* is frequently present, but is sometimes wanting. It is usually wedge-shaped, attached by its base to the upper part of the joint, and only partially separating the small oval articular surfaces.

Fig. 124.

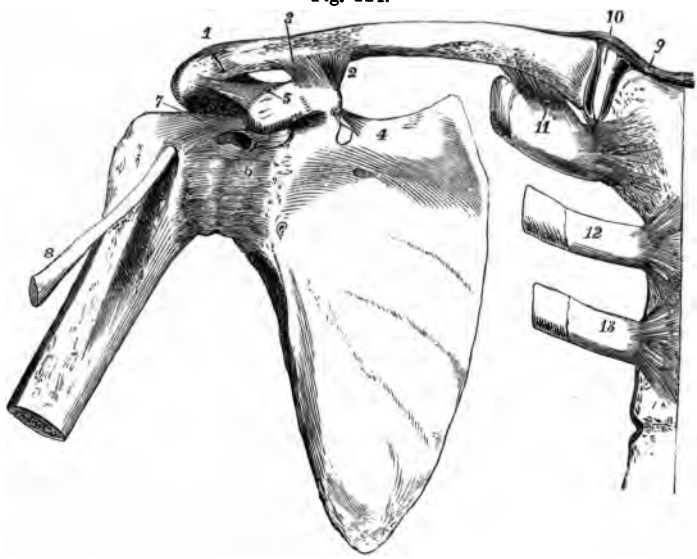


Fig. 124.—View from before of the Articulations of the Shoulder Bones. ⅛

1, acromio-clavicular articulation; 2, conoid, and 3, trapezoid part of the coraco-clavicular ligament; 4, is near the supra-scapular or coracoid ligament; 5, placed on the coracoid process, points to the coraco-acromial or deltoid ligament; 6, is placed on the front of the capsular ligament of the shoulder-joint; 7, the coraco-humeral ligament or accessory part of the capsular; above 6, an aperture in the capsular ligament at the place where a part of the tendon of the subscapularis muscle pierces the capsular ligament, and is sometimes connected with a synovial bursa; 8, tendon of the glenoid head of the biceps muscle issuing between the tuberosities; 9, right half of the interclavicular ligament; 10, interarticular fibro-cartilage of the sterno-clavicular articulation, shown by removing the anterior sterno-clavicular ligament and synovial membrane; 11, the costo-clavicular or rhomboid ligament; 12 and 13, the cartilage and small part of the second and third ribs attached by their anterior costo-sternal ligaments. (See also Fig. 120.)

The *coraco-clavicular ligament*, which connects the clavicle with the coracoid process of the scapula, is divisible into two parts, each known by a particular name. The *conoid ligament*, which is the posterior or internal fasciculus, broad above, narrow below, is attached inferiorly to the inner part of the root of the coracoid process, and superiorly to a tubercle on the inferior surface of the clavicle below the convex margin of its outer curve: its fibres are directed backwards and upwards. The *trapezoid ligament*, the anterior or external fasciculus, slopes upwards, backwards, and outwards from the inner border of the coracoid process to an oblique line extending outwards from the tubercle to which the conoid ligament is attached, and is inserted at right angles to the line of attachment of that ligament to the clavicle. In the angle between the conoid and trapezoid ligaments there is frequently present a synovial bursa.

MOVEMENTS.—The movements allowed at the clavicular articulations are limited, not so much by the forms of the articular surfaces, as by the costo-clavicular and coraco-clavicular ligaments and the position of the thoracic wall. When the clavicle is forcibly depressed, as in lifting a heavy weight, it presses upon the first rib, the upper border of its inner end rises above the sternum, and the interarticular cartilage and inter-clavicular ligament are put upon the stretch. When the shoulders are drawn backwards and downwards, the angle between the clavicle and the upper border of the scapula is increased, by the descent of the scapular arch on the conical wall of the thorax. In raising and depressing the arm to its full extent, there is not only vertical motion at the shoulder joint, but also motion at the sterno-clavicular and acromio-clavicular articulations.

LIGAMENTS OF THE SCAPULA.—There are two ligaments which stretch from one part of the scapula to another. 1. The *coracoid* or *supra-scapular ligament* (ligamentum proprium posterius), is a thin flat band of fibres, attached by its extremities to the opposite margins of the notch at the root of the coracoid process, which it thus converts into a foramen for the transmission of the supra-scapular nerve, the corresponding artery most commonly passing above it. 2. The *coraco-acromial ligament* (ligamentum proprium anterius), broad, firm, and triangular, is attached by its broader extremity to the outer edge of the coracoid process, and by the narrower to the tip of the acromion. Its inferior surface looks downwards upon the shoulder-joint, the superior is covered by the deltoid muscle.

THE SHOULDER JOINT.

In this articulation the large and hemispherical head of the humerus is opposed to the much smaller surface of the glenoid cavity of the scapula. The bones are retained in position, not by the direct tension of strong ligaments, which would have restricted too much the movements of the joint, but by surrounding muscles and atmospheric pressure.

The *capsular ligament* is attached to the scapula round the margin of the glenoid cavity, and to the humerus at the place where the neck springs from the tuberosities and shaft. It extends furthest down the humerus on the internal or inferior aspect, and is strongest on the superior aspect. The laxity of the capsule is such that the humerus drops away from the glenoid cavity

Fig. 125.

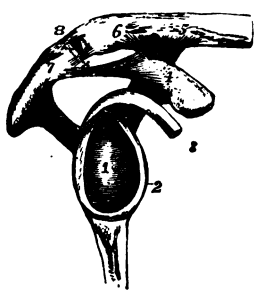


Fig. 125.—VIEW OF THE GLENOID CAVITY AND LIGAMENTS BETWEEN THE SCAPULA AND CLAVICLE OF THE RIGHT SIDE. ½

1, glenoid fossa, its cartilaginous surface; 2, the glenoid ligament or fibrous border; 3, the tendon of the biceps muscle seen in connection with the upper part of the glenoid fossa and ligament; 4, is placed on the upper surface of the coracoid process; 5 and 6, on the adjacent part of the clavicle; 4 to 5, the conoid; 4 to 6, the trapezoid portion of the coraco-clavicular ligament; 7, is placed on the apex of the acromion process; 4 to 7, the coraco-acromial ligament; 8, is above the acromio-clavicular articulation, which is represented as open anteriorly, showing a wedge-shaped inter-articular cartilage attached above to the superior acromio-clavicular ligament; ×, the inferior acromio-clavicular ligament.

as soon as its muscular connections are detached. Superiorly and posteriorly the capsule is strengthened by the tendons of the supra spinatus, infra-spinatus,

and teres minor muscles, which are intimately connected with it, as they pass over it to reach the great tuberosity of the humerus. Anteriorly the tendon of the subscapularis muscle comes into direct contact with the synovial membrane, which is prolonged upon it through an oval opening. The insertion of the capsule is likewise interrupted opposite the bicipital groove, to give passage to the long tendon of the biceps muscle.

The *coraco-humeral*, or accessory ligament, is a broad bundle of fibres extending obliquely over the upper and outer part of the articulation ; it is attached to the root of the coracoid process, and thence descends towards the greater tuberosity of the humerus, intimately connected with the capsule.

The *glenoid ligament* is a firm fibrous band, about two lines deep, which is fixed to the edge of the glenoid fossa, and, by elevating the border of the cavity, renders it a little deeper. The upper part of it is connected with the tendon of the long head of the biceps muscle, which is also fixed into the upper part of the glenoid fossa, within the capsule of the joint.

The *synovial membrane* is reflected uninterruptedly from the glenoid cavity on the inner surface of the fibrous capsule to the humerus, but its form is complicated by its relation to the tendons of the biceps and subscapularis muscle. The long tendon of the biceps muscle, traversing the joint in its course from the upper border of the glenoid cavity to the bicipital groove, is enclosed in a tubular sheath, formed by an offset or process of the synovial membrane, which is continued down upon it beyond the fibrous capsule into the bicipital groove, and is thence reflected upwards upon it to

Fig. 126.

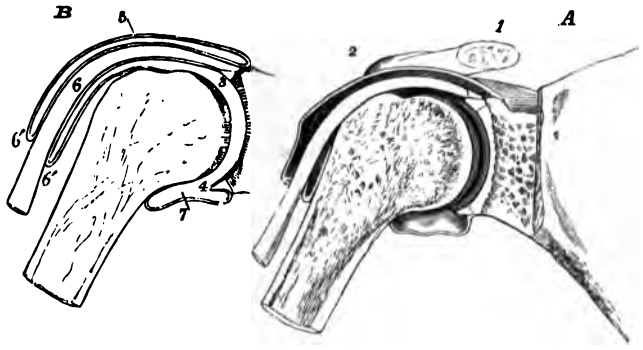


Fig. 126.—A, Section through the Shoulder Joint, passing from within outwards through the tendon of the Biceps and Bicipital Groove, somewhat diagrammatic, to show the Synovial Cavity of the Joint, &c. ½

B, Outline of the same, to show the inflection of the Synovial Membrane over the Tendon.

1, placed above the sawn end of the outer part of the clavicle ; 2, is near the acromial end ; 3, the cavity of the shoulder joint close to the upper part of the glenoid head, where there are seen the section of the cartilages on the head of the humerus and in the glenoid cavity of the scapula, the glenoid ligament, and the origin of the tendon of the biceps muscle ; 4, is in the lower part of the cavity of the joint, indicating the section of the glenoid ligament in that situation ; 5, the upper part of the capsular ligament and synovial membrane ; 6, the tendon of the biceps as it passes out of the joint into the bicipital groove ; 6′, 6′, the tubular prolongation of the synovial membrane round the tendon ; 7, the reflection of the synovial membrane on the humerus within the lower part of the capsular ligament.

its origin, where it again becomes continuous with the synovial membrane of the capsule in such a manner as to preserve the integrity of the membrane. The bursal prolongation of the synovial membrane on the tendon of the subscapularis muscle is of variable extent, sometimes scarcely existing, sometimes forming a considerable pouch on the venter of the scapula.

Subacromial Bursa.—Superficial to the muscles covering the top of the joint is a considerable bursa mucosa, by means of which the contiguous surfaces of the coracoid and acromion processes, and of the coraco-acromial ligament and deltoid muscle are lubricated, so as to facilitate the movements of the subjacent head of the humerus.

Movements.—Great freedom of movement of the humerus in every direction is admitted at the shoulder-joint; but superiorly and posteriorly the extent of the movement is somewhat limited by the margin of the acromion. When the arm is raised, the great tuberosity of the humerus becomes locked against the acromion as soon as the position is reached in which the limb lies at right angles to the trunk, and all further elevation is accomplished by movements in the sterno-clavicular and acromio-clavicular articulations. The arch formed by the acromion, the coracoid process and the deltoid ligament, lined by the subacromial bursa, forms a sort of secondary socket, in which the extremity of the humerus, covered by the tendons inserted into the great tuberosity, revolves, and against which it is pressed when the weight of the body is made to rest upon the arms: in quadrupeds, the weight of the body is transmitted through the glenoid fossa to the humerus.

ARTICULATIONS OF THE FOREARM AND ELBOW.

Union of the Radius and Ulna.—The bones of the forearm are united by a superior and inferior articulation and an inter-osseous membrane.

Fig. 127.

Fig. 127.—The upper part of the Ulna, with the Orbicular Ligament of the Radius. ½

1, upper division of the sigmoid surface on the olecranon; 2, extremity of the coronoid process; 5, orbicular ligament.

In the *superior radio-ulnar articulation*, the connection of the head of the radius with the small sigmoid cavity of the ulna is effected by means of the *annular* or *orbicular ligament*, a strong band of fibres attached to the ulna in front and behind at the extremities of the small sigmoid cavity, and forming four-fifths of a ring which encircles the head of the radius and binds it firmly in its situation. The outer surface is connected with the external lateral ligament of the elbow, whose fibres are inserted into it; the deep surface is smooth, and is lined by the synovial membrane of the elbow joint.

The *inferior radio-ulnar articulation*.—The connection between the semilunar surface of the radius and the lower end of the ulna is effected by means of a fibro-cartilage, a synovial membrane, and some scattered ligamentous fibres in front and behind. The *triangular fibro-cartilage* is a thick plate attached by its base to a ridge separating the carpal from the ulnar articulating surface of the radius; and by its apex to a depression at the root of the styloid process of the ulna, and to the side of that process. Its upper surface looks towards the ulna, its lower towards the cuneiform bone,

and it separates the inferior radio-ulnar articulation from the wrist joint. The *synovial membrane*, sometimes called from its looseness *membrana sacciformis*, extends partly upwards between the radius and ulna, partly horizontally inwards between the ulna and triangular fibro-cartilage. When the fibro-cartilage is perforated, as is occasionally the case, this synovial membrane is continuous with that of the wrist joint.

Fig. 128.

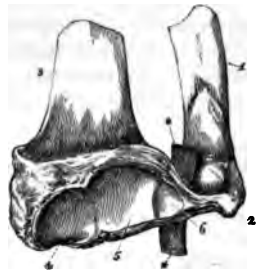


Fig. 128.—The lower parts of the Radius and Ulna, with the Triangular Fibro-Cartilage connecting them. $\frac{2}{3}$

1, ulna; 2, its styloid process; 3, radius; 4, the part of the articular surface for the scaphoid bone; 5, that for the semilunar bone; 6, lower surface of the triangular fibro-cartilage; * *, a piece of whalebone passed between the fibro-cartilage and the ulna.

The *interosseous membrane* or *ligament* of the forearm is a thin, flat, fibrous membrane, the direction of whose fibres is for the most part obliquely downwards and inwards, and which extends between the contiguous borders of

Fig. 129.

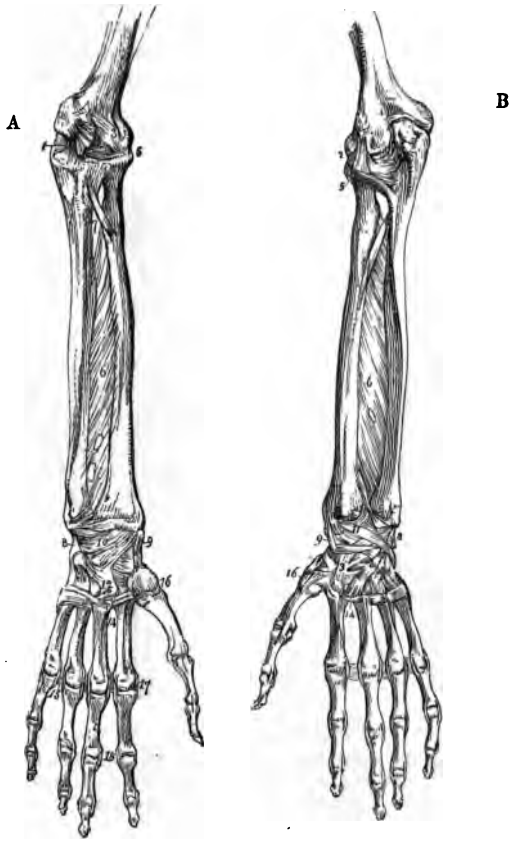


Fig. 129.—A, Front, and B, Back view of the Articulations of the Forearm, Wrist and Hand. $\frac{1}{3}$

1, the internal lateral ligament of the elbow joint; 2, the external lateral; 3, the anterior; 4, points to the posterior; 5, orbicular ligament of the radius; 6, interosseous membrane; 7, oblique or round ligament; 8, internal lateral ligament of the wrist; 9, external; 10, anterior; 11, posterior; 12, palmar, and 13, dorsal carpo-metacarpal ligaments; 14, ligaments connecting metacarpal bones; 15, transverse metacarpal ligament; 16, carpo-metacarpal ligament of the thumb; 17, lateral ligaments connecting the phalangeal with the metacarpal bones; 18, lateral ligaments of the phalanges.

the radius and ulna. Its superior border is placed about an inch below the tubercle of the radius, leaving a space (hiatus inter-osseus) through which the posterior inter-osseous vessels pass. This space is diminished in size by the *round or oblique ligament*, a thin, narrow fasciculus of fibres extending obliquely downwards and outwards from the coronoid process, to be attached to the radius about half an inch below the tubercle. Other small bundles of fibres, having the same direction as the round ligament, are often to be found at intervals, decussating with the fibres of the inter-osseous ligament on its posterior surface.

MOVEMENT OF THE RADIUS ON THE ULNA.—The disposition of the annular ligament allows the head of the radius to rotate freely within it, while the lower end of the radius, bound by the triangular fibro-cartilage to the styloid process of the ulna, has a freedom of circumduction round that point, by which the hand is brought into the prone or supine position. Thus in pronation and supination the movement of the radius describes a part of a cone, the axis of which extends from the centre of the head of the radius to the styloid process of the ulna.

THE ELBOW JOINT.—The lower extremity of the humerus is in contact with the ulna and radius at the elbow, and forms with them a hinge-joint. The greater sigmoid cavity of the ulna articulates with the trochlea of the humerus, so as to admit of flexion and extension only; while the cup-shaped depression on the head of the radius is fitted to turn freely on the rounded capitulum. These bones are united principally by lateral ligaments.

Fig. 130.

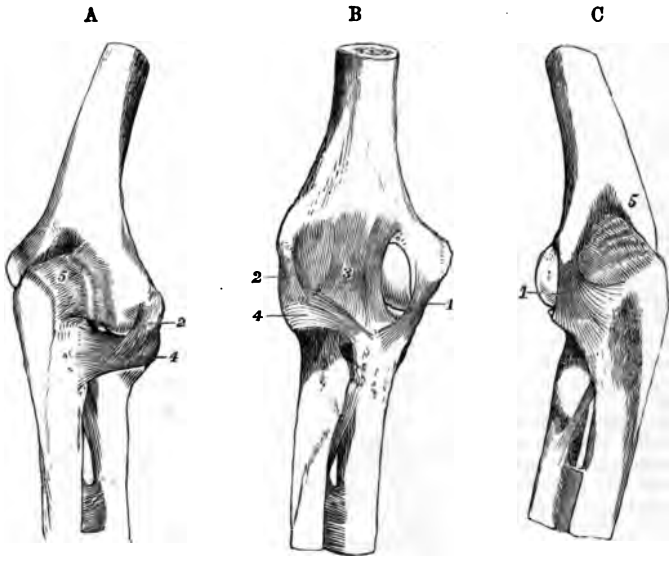


Fig. 130.—LIGAMENTS OF THE ELBOW-JOINT. ½

A, from the outer side and behind; B, from the front; C, from the inner side and behind. 1, internal lateral ligament; 2, external lateral; 3, the middle strongest part of the anterior ligament; 4, orbicular ligament; 5, posterior, represented as wrinkled from relaxation in extension. In these figures the round ligament and upper part of the inter-osseus membrane are also represented below the elbow-joint.

The *internal lateral ligament*, composed of diverging and radiating fibres, is divisible into an anterior and a posterior part. The anterior part radiates from the front of the internal condyloid eminence of the humerus, and is inserted into the coronoid process, along the inner margin of the sigmoid cavity. The posterior part, of the same triangular form, passes from the under and back part of the condyloid eminence downwards to the inner border of the olecranon; and some fibres are connected with a small transverse band over the notch between the olecranon and the coronoid process.

The *external lateral ligament*, intimately connected with the tendinous attachment of the extensor muscles, is shorter and much narrower than the internal. It is attached superiorly to the external condyloid eminence of the humerus, and inferiorly becomes blended with the annular ligament of the radius; some of its hinder fibres are prolonged to the external margin of the ulna.

The *anterior ligament* consists of a thin sheet of fibres extending downwards from above the coronoid pit of the humerus, and protecting the anterior part of the synovial membrane; it is strongest in its middle part.

The *posterior ligament* is comparatively thin and weak, and consists of loose and irregular fibres passing transversely across the olecranon fossa of the humerus, and from the sides of that fossa to the olecranon process, thus completing the capsule of the joint behind.

Fig. 131.

Fig. 131.—Vertical Antero-Posterior Section of the Elbow-Joint through the Greater Sigmoid Cavity of the Ulna and corresponding Trochlear surface of the Humerus. ½

1, cut surface of the humerus; 2, that of the ulna; 3, posterior part, and 4, anterior part of the synovial cavity of the joint; 5, orbicular ligament enclosing the head of the radius; 6, tendon of the biceps muscle at its insertion into the tuberosity; 7, is at the lower end of the round ligament.

The *synovial membrane* extends upwards on the humerus so far as to line the fossæ for the coronoid and olecranon processes, and is loose and vascular in the latter positions. It is prolonged round the head and neck of the radius, which it separates from the smaller sigmoid cavity and annular ligament.

Movements.—Flexion and extension are the only movements which can take place between the humerus and ulna, and these are limited by the locking of the coronoid and olecranon processes in the respective fossæ of the humerus which receive them. The path of motion is in a nearly vertical plane, with a direction slightly outwards. The inner lip of the trochlea being prominent below, forms an expansion which corresponds to an inward projection of the coronoid part of the ulnar surface, and is only brought into use in flexion; and the outer lip of the trochlea being everted at the upper and back part, forms a surface which is only in use in complete extension, and which then corresponds to a surface on the outer aspect of the olecranon, which comes in contact with no other part of the humerus. In flexion and extension the radius moves by its cup-shaped head upon the capitulum, and on the groove between that process and the trochlea, by a ridge internal to the cup. It is most completely in contact with the humerus in the position of semi-flexion and semi-pronation. In full extension and supination, the anterior margin of the head of the radius is barely in contact with the inferior surface of the capitulum. In full flexion, the margin of the head of the radius rests against the pit above the capitulum.

THE WRIST-JOINT AND ARTICULATIONS OF THE HAND.

THE RADIO-CARPAL ARTICULATION, or wrist-joint, is formed between the radius and triangular fibro-cartilage above, and the scaphoid, semi-lunar and cuneiform bones below. The superior surface, concave both transversely and from before backwards, is subdivided by linear elevations into three parts corresponding to the three bones below, the innermost part being formed by the fibro-cartilage. The inferior surface, convex in both directions, is prolonged further down upon the carpal bones behind than in front.

The *internal lateral ligament* is a rounded cord passing directly downwards from the extremity of the styloid process of the ulna, to be attached to the cuneiform bone; it also sends some fibres to the anterior annular ligament and the pisiform bone.

The *external lateral ligament* extends from the styloid process of the radius to a rough surface on the outer side of the scaphoid bone, some of its fibres being prolonged to the trapezium, and also to the anterior annular ligament of the wrist.

The *anterior ligament* (radio-carpal), broad and membranous, consists partly of fibres which have a nearly transverse direction, partly of others, which diverge as they descend from the anterior border of the radius to the scaphoid, semi-lunar, and cuneiform bones: some of them are continued to the os magnum.

The *posterior ligament* extends obliquely downwards and inwards, from the extremity of the radius, to the posterior surface of the first row of the carpal bones, especially the cuneiform bone; its fibres are prolonged some distance on the surface of the carpal bones.

The *synovial membrane* is reflected from the radius and the triangular fibro-cartilage, on the surrounding ligaments, and after lining these, passes to the opposed surface of the carpal bones.

THE CARPAL ARTICULATIONS.—The bones of the carpus, the pisiform excepted, are so arranged in two rows, that while only slight movement can take place between the members of each row, a considerable amount of movement is possible between the two rows. The surface presented by the first row to the second is concave both transversely and from before backwards in the greater part of its extent, but at its outer side it is bounded by the convex part of the scaphoid bone. The opposing surface of the second row is concavo-convex from without inwards, the concavity being formed by the trapezium and trapezoid, the convexity by the os magnum and unciform bone.

The *two rows of carpal bones* are united by dorsal, palmar, and lateral ligaments. The *lateral ligaments* are placed one at the radial, the other at the ulnar border of the carpus; the former connects the scaphoid bone with the trapezium, the latter the cuneiform with the unciform. The *dorsal ligaments* consist of fibres passing in various directions; the *palmar ligaments* are chiefly composed of fibres converging towards the os magnum.

The *bones of the first row*, the pisiform bone excepted, are united by interosseous, and by dorsal and palmar ligaments. The *inter-osseous* ligaments, placed on the sides of the semi-lunar bone on a level with its superior surface, connect it with the scaphoid and cuneiform bones, thus completing the inferior wall of the radio-carpal joint. The *dorsal* and *palmar* ligaments, each two in number, extend transversely on the dorsal and palmar surfaces from the scaphoid bone to the semi-lunar, and from the semi-lunar to the cuneiform

The *bones of the second row* are connected by similar means. The *dorsal* and *palmar* ligaments, each three in number, pass transversely between the contiguous bones. The inter-osseous ligaments are generally three (but

Fig. 132.

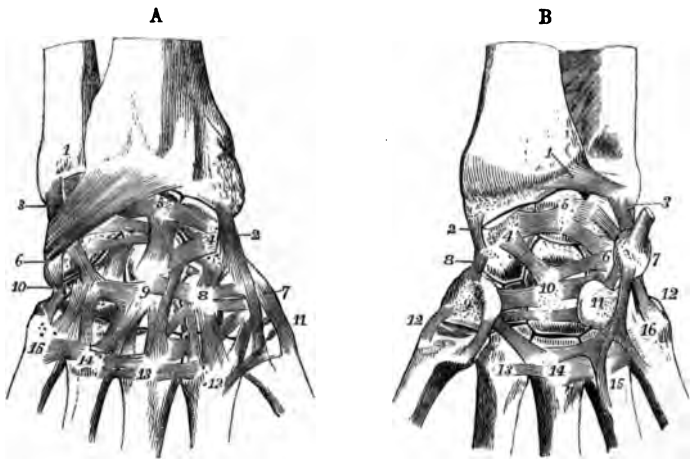


Fig. 132, A.—Dorsal view of the deeper Ligaments of the Wrist-Joint, and of the Carpal and Carpo-Metacarpal Articulations (after Arnold). ½

1, lower part of the ulna; 2, external lateral ligament of the wrist-joint; 3, internal; near it, descending obliquely to 6, from the radius, the dorsal radio-carpal ligament; 4 to 5, transverse dorsal ligaments of the first row: 4, is on the scaphoid; 5, on the semilunar bone; 6, cuneiform bone, with the attachment of the dorsal radio-carpal ligament; 7, trapezium; 8, trapezoid; 9, os magnum; 10, unciform; 11 to 15, first to fifth metacarpal bones; 7 to 8, 8 to 9, and 9 to 10, transverse dorsal ligaments of the second row of carpal bones; 4 to 8, 4 to 9, 5 to 9, and others, dorsal ligaments between the first and second row; 8 to 12, 9 to 13, and others, dorsal ligaments from the second row to the metacarpal bones; between the metacarpal bones, from 11 to 15, the dorsal inter-metacarpal ligaments.

Fig. 132, B.—Palmar view of the Ligaments of the Wrist-Joint, and of the Carpal and Carpo-Metacarpal Articulations. ½

The anterior radio-carpal ligament has been removed: 1, anterior ligament of the lower radio-ulnar articulation; 2, external, and 3, internal lateral ligament of the wrist-joint; 4, scaphoid bone; 5, semilunar; 6, cuneiform; 7, pisiform, with the tendon of flexor carpi ulnaris attached; 4 to 5, and 5 to 6, palmar transverse ligaments of the first row; 8, external lateral ligament between the first and second row of carpal bones; 9, trapezium (the trapezoid is not numbered); 10, os magnum; 11, hooked process of the unciform bone; 9 to 10, 10 to 11, and others, transverse palmar ligaments of the second row; 4 to 10, and 6 to 10, some of the palmar ligaments uniting the two rows, converging on the os magnum; 7 to 11, ligament from the pisiform bone to the unciform process; 7 to 16, ligament from the pisiform to the fifth metacarpal bone; 12, external ligament of the first carpo-metacarpal articulation, the internal of which is also shown; 13, 14, 15, 16, the proximal ends of the second to the fifth metacarpal bones, on which the palmar transverse, and on three of them, a set of piso-metacarpal ligaments are shown.

sometimes only two) in number, a strong ligament being placed between the os magnum and unciform bones, another between the trapezoid and trapezium, and a slender ligament between the os magnum and trapezoid. A small inter-osseous ligament is also sometimes found between the os magnum and the scaphoid. (Fig. 133.)

The *synovial cavity* of the carpal articulations is extensive and complicated. Passing between the two rows of carpal bones, it sends likewise two processes between the three bones of the first row, and three between the four bones of the second. It is further continued downwards into the four lower carpo-metacarpal and three intermetacarpal articulations of the ulnar side. In some rare cases there is continuity with the synovial membrane of the wrist-joint, by deficiency of one of the interosseous ligaments between the carpal bones.

Fig. 133.

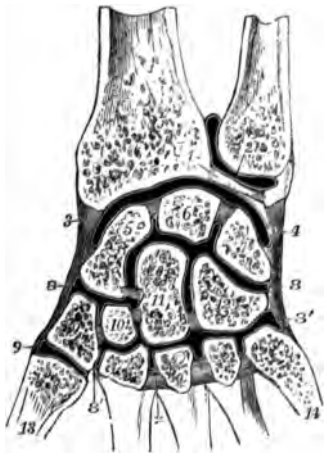


Fig. 133.—Transverse Section of the Synovial Cavities of the Inferior Radio-Ulnar, Radio-Carpal, Inter-Carpal, and Carpo-Metacarpal Articulations. ½

1, points to the triangular fibro-cartilage below the ulna; 2, placed on the ulna, points to the cavity of the sacciform synovial membrane; 3, external lateral, and 4, internal lateral ligament, and between them the synovial cavity of the wrist; 5, scaphoid bone; 6, semilunar; 7, cuneiform; 8, 8, upper portion, and 8′, 8′, lower portion of the general synovial cavity of the intercarpal and carpo-metacarpal articulations; between 5 and 6, and 6 and 7, the interosseous ligaments are seen separating the carpal articular cavity from the wrist-joint; between the four carpal bones of the lower row, and between the magnum and scaphoid the interosseous ligaments are also shown; the upper division of the synovial cavity communicates with the lower between 10 and 11, and between 11 and 12; ×, marks one of the three interosseous metacarpal ligaments; 9′, separate synovial cavity of the first carpo-metacarpal articulation; 13, first, and 14, fifth, metacarpal bone.

Note. It is to be observed that in this figure, and in others of a like kind which represent the joint cavities, the white or black lines indicating the synovial membranes are, for the sake of clearness, generally represented as passing over the surfaces of the articular cartilages, although this is not the case in nature. These lines therefore must be held to represent merely the whole continuity of the articular, or, as they are often called, the synovial surfaces.

The *pisiform bone* is articulated by a fibrous capsule and synovial membrane with the cuneiform bone. Inferiorly it is united by two strong ligaments with the unciform and fifth metacarpal bones, and is sometimes also connected with other metacarpal bones; superiorly it receives the tendon of the flexor carpi ulnaris muscle. The synovial membrane is usually distinct, but sometimes communicates with that of the radio-carpal articulation.

The *anterior annular ligament* of the wrist is a strong and thick band, which extends from the prominences made by the trapezium and scaphoid bone on the radial side of the carpus, directly across to the pisiform bone and unciform process, and converts the transverse arch of the carpus into a ring through which the flexor tendons of the digits pass into the hand.

The *posterior annular ligament*, placed at the back of the wrist, is only a thickened part of the aponeurosis of the forearm. It extends from the lower part of the radius, at its outer border, to the inner part of the cuneiform and pisiform bones, and serves to bind down the extensor tendons.

CONNECTION OF THE METACARPAL BONES WITH THE CARPUS, AND WITH EACH OTHER.

The four inner metacarpal bones are bound together at their distal extremities by thin fibres passing between them, and constituting on their palmar

aspect, the *transverse ligament*. At their proximal extremities they are united to one another and to the carpal bones in articulations, the common synovial lining of which is derived from that of the carpal joint. In these articulations the four metacarpal bones are bound together by three *dorsal*, and three *palmar*, and by strong *interosseous* ligaments. There are also *dorsal* ligaments uniting these metacarpal bones with the carpus, each having two such ligaments except the fifth. Thus to the second, or that of the fore-finger, a thin fasciculus of fibres passes from the trapezium, and another from the trapezoid bone; the third receives one from the trapezoid, and from the os magnum; the fourth from the os magnum and also from the unciform; but the fifth is connected with the unciform only. The *palmar* ligaments are not so well defined; there is a single band to each bone, except that of the little finger. There is likewise an interosseous band in one part of the carpo-metacarpal articulation, connecting the lower and contiguous angles of the os magnum and unciform to the adjacent angle of the third metacarpal bone. This ligament is usually surrounded by a part of the general synovial membrane, but sometimes it separates the cavity between the unciform and two inner metacarpal bones from the rest of the joint.

The *first metacarpal bone* is unconnected with the others, and is articulated with the trapezium by an external and internal ligament, a capsular investment, and a distinct synovial membrane.

ARTICULATIONS OF THE METACARPAL BONES WITH THE PHALANGES, AND OF THE PHALANGES WITH EACH OTHER.

The rounded head of each of the last four metacarpal bones, being received into the slight concavity in the extremity of the first phalanx, is maintained in its position by two lateral ligaments, an anterior ligament, and a synovial membrane.

The *lateral ligaments* consist of dense and thick fasciculi of fibres, placed one at each side of the joint; they are attached each by one extremity to the side of the metacarpal bone, and by the other to the anterior ligament and the contiguous extremity of the phalanx. The direction of the fibres is downwards and forwards.

Fig. 134.

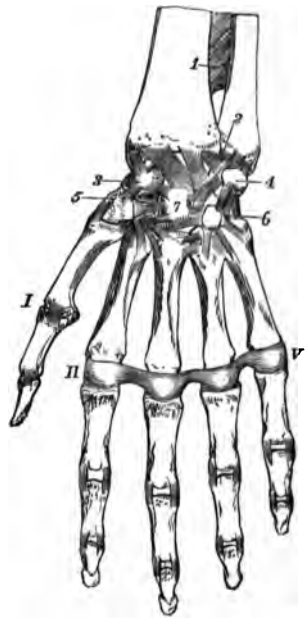


Fig. 134.—GENERAL VIEW OF THE ARTICULATIONS OF THE WRIST AND HAND FROM BEFORE. ½

1, lower part of the interosseous membrane; 2, and from that point across the lower end of the radius, the palmar radio-carpal ligaments; 3, scaphoid bone; 4, pisiform; 5, trapezium; 6, unciform; 7, os magnum, with most of the deeper ligaments uniting these bones; I, first metacarpo-phalangeal articulation with its external lateral ligament; II to V, transverse metacarpal ligament: in the several phalangeal articulations the lateral ligaments are shown; in the first the external only is visible.

The *anterior* or *palmar ligament* or rather *fibrous plate*, occupies the interval between the lateral ligaments on the palmar aspect of each joint; it

is a thick and dense fibro-cartilaginous structure, which is firmly united to the first phalangeal bone, and but loosely adherent to the metacarpal. It is continuous at each side with the lateral ligament, so that the three form one undivided structure which covers the joint, except on the dorsal aspect. Its palmar surface is grooved for the flexor tendon, whose sheath is connected to it at each side; the other surface, looking to the interior of the joint, is lined by the synovial membrane, and supports the head of the metacarpal bone. In the joint of the thumb there are two sesamoid bones, one situated at each side, which are connected with its ligaments.

Fig. 135.

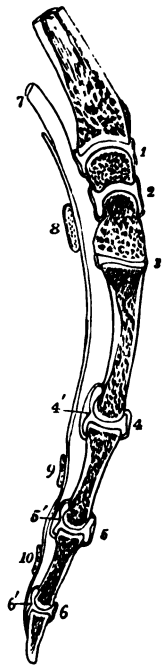


Fig. 135.—Longitudinal Antero-Posterior Section through the lower part of the Radius, the Carpus, Semilunar Bone, Os Magnum, Metacarpal Bone, and Phalanges of the Middle Finger, to show the shape of the Articular Surfaces and Synovial Cavities between these several Bones. ½

1, synovial cavity of the wrist-joint; 2, intercarpal cavity; 3, carpo-metacarpal cavity; 4, metacarpo-phalangeal cavity; 5 and 6, phalangeal cavities; 4′, 5′, and 6′, the palmar fibro-cartilaginous plates which are attached to the base of the several phalanges; 7, indicates the place of the tendons of the long flexor muscles; 8, a transverse section of the anterior annular ligament; 9 and 10, transverse retinacula or vaginal ligaments of the flexor tendons on the first and second phalanges.

A *synovial membrane* is present in each joint, and invests the surface of the ligaments which connect the bones.

The *phalanges are articulated with one another*, on the same plan as that which obtains in the articulations between the bases of the proximal phalanges with the metacarpal bones.

Movements of the Wrist and Fingers.—In the radio-carpal and common carpal articulations, there is allowed not only flexion and extension, but a certain amount of lateral bending. The superior articular surfaces of both ranges of carpal bones being prolonged further on the dorsal than on the palmar aspect, over-extension is allowed in both joints to some degree. In over-extension the opposing surfaces are most perfectly adapted to each other; in flexion, they are least so. The kind of movement which is allowed between the carpal and metacarpal bones is best illustrated by placing the hand in such a position that the weight of the body is rested upon the open palm. The metacarpal range, which naturally is concave towards the palm, is flattened; and the metacarpal, interosseous, and palmar ligaments are thus tightened, while a slight separation of the opposed surfaces of the bones takes place; so also the palmar carpo-metacarpal ligaments are tightened, and both palmar and interosseous ligaments of the second range of carpal bones. The convex part of the os magnum and unciform bone, fitted in those circumstances into the concavity of the first range, is a little wider than the part usually in contact with it; and thus, while the bones of the second range are separated from the distal side, those of the first range are pressed still more separate from the palmar aspect, and their interosseous ligaments are put upon the stretch. The whole arrangement secures elasticity. The fourth and fifth metacarpal bones, being more moveable at their carpal articulation than the second and third, bend forward very distinctly in shutting the hand, thus rendering the palm more hollow, and bringing the tips of the fingers more closely together: the movement is one of coaptation. At the phalangeal articulations the only movement allowed is that of flexion and extension, and over-extension is pre-

vented by the ligamentous structures in front of the joints. At the metacarpo-phalangeal articulations there is allowed, in addition, a movement of abduction and adduction, but that chiefly in the extended position. In the articulation of the metacarpal bone of the thumb with the trapezium every movement is allowed except rotation, which is prevented by the shape of the articular surfaces.

ARTICULATIONS OF THE PELVIS.

ARTICULATION OF THE PELVIS WITH THE LAST LUMBAR VERTEBRA.—The fifth lumbar is united to the first sacral vertebra by anterior and posterior ligaments of the body, ligamenta subflava of the arch and interspinous ligaments, and by an intervertebral plate, all of which are similar to those between the vertebræ above. It is also attached to the pelvis by two other ligaments, as follows :—

The *sacro-vertebral ligament* extends obliquely from the tip of the transverse process of the last lumbar vertebra downwards to the depressed lateral part of the base of the sacrum ; its form is triangular, and its fibres diverge as they descend, some of them joining the anterior sacro-iliac ligament.

The *ilio-lumbar ligament* is extended horizontally between the summit of the transverse process of the last lumbar vertebra and the iliac crest of the innominate bone ; it is inserted into the latter at the back part of the iliac fossa, where its fibres expand somewhat, so as to give it a triangular form.

ARTICULATION OF THE SACRUM AND COCCYX, AND OF THE PIECES OF THE COCCYX.—These articulations are effected by an *anterior ligament*, consisting of irregular fibres placed in front of the bones, a prolongation of the anterior common ligament of the vertebræ ; by a *posterior ligament* more strongly marked, composed of fibres which descend upon the bones of the coccyx from the margin of the inferior orifice of the sacral canal ; and by *intervertebral discs* between the contiguous surfaces of the bones.

A synovial membrane has been stated by Cruveilhier ("Anatomie descriptive," tom. i. p. 356. Paris, 1834), to be present in those cases in which the coccyx is freely moveable. This is in conformity with the more recent observations of Luschka on the other intervertebral discs. In the male, after middle life, the union between the sacrum and coccyx, and that between the pieces of the latter, is usually ossific. In the female this change does not generally occur till a more advanced age ; the pieces of the coccyx uniting one to another in the first place, and the joint between the sacrum and coccyx not ossifying till old age. The mobility seems to increase during pregnancy.

THE SACRO-ILIAC ARTICULATION, often named the *sacro-iliac symphysis*, or *synchondrosis*, is formed between the adjacent portions of the sacrum and ilium, the auricular surfaces of which are coated with cartilage, and the remaining parts are united by strong ligaments (see fig. 139).

The auricular cartilaginous plate unites the bones with great firmness. When the ilium and sacrum are forcibly torn asunder, this plate usually separates into two layers, one of which adheres to the surface of each bone. In some instances a small cavity naturally exists between these two plates of cartilage. Even when separated in part, however, these plates are very closely applied, and admit only a limited amount of movement. They are then sometimes slightly united by delicate tissue, and in advanced life, small spaces containing glairy fluid are liable to be formed between them. The cavity of this articulation becomes more apparent, and the ligaments somewhat looser before parturition.

The *posterior sacro-iliac ligament*, much the thicker, consists of a large number of strong irregular fibres extending across the interval between the posterior rough portion of the lateral surface of the sacrum and that part of

the ilium which projects beyond the dorsum of the sacrum. A superficial band extending downwards from the posterior superior iliac spine to the third or fourth piece of the sacrum, in a direction different from the other fibres, is distinguished as the *oblique sacro-iliac ligament.*

The *anterior sacro-iliac ligament* consists of thin irregular fibres passing between the sacrum and os innominatum on their pelvic surfaces.

Fig. 136.

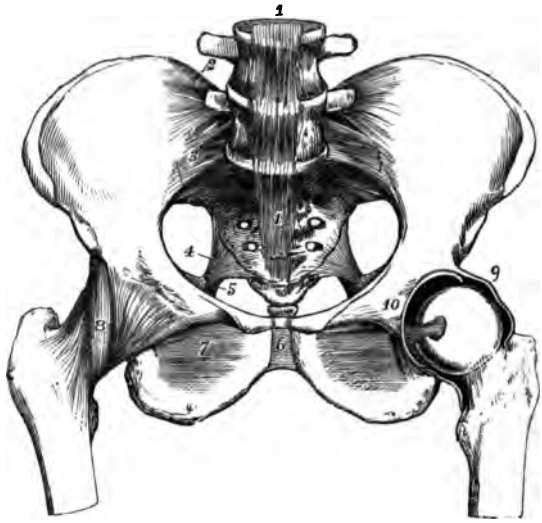


Fig. 136.—ARTICULATIONS OF THE PELVIS AND HIP-JOINT, SEEN FROM BEFORE. THE ANTERIOR HALF OF THE CAPSULAR LIGAMENT OF THE LEFT HIP-JOINT HAS BEEN REMOVED, AND THE FEMUR ROTATED OUTWARDS. ¼

1, 1, anterior common ligament of the bodies of the vertebræ passing down over the two lowest lumbar vertebræ to the front of the sacrum and coccyx; 2, ilio-lumbar ligament; 3, anterior sacro-iliac ligament; between 2 and 3, on the right side, the sacro-vertebral ligament is shown, but not with sufficient distinctness; 4, placed in the great sacro-sciatic foramen, points to the lesser sacro-sciatic ligament; 5, a portion of the great sciatic ligament; 6, the anterior ligament of the symphysis pubis; 7, the obturator membrane or ligament; 8, the capsular ligament of the right hip-joint: the figure is placed on its ilio-femoral band; 9, the upper part of the divided capsular ligament of the left hip-joint near the place of its attachment to the border of the acetabulum; 10, placed on the os pubis of the left side above the transverse ligament of the acetabular notch. The head of the femur is withdrawn partially from the socket, so as to show the round ligament stretched from the transverse ligament.

THE SACRO-SCIATIC LIGAMENTS.—The *posterior*, or *great sacro-sciatic ligament*, elongated, broad, and triangular, is placed at the inferior and posterior part of the pelvis, whose lower aperture it assists in closing. Its base or broader part is attached to the postero-inferior iliac spine and to the side of the sacrum and coccyx; whilst its other extremity is fixed along the inner surface of the ischial tuberosity, where it expands somewhat, and sends upwards and forwards along the margin of the ischial ramus a falciform process, the border of which is continuous with the obturator fascia, forming the inferior attachment of that structure.

The *anterior*, or *small sacro-sciatic ligament*, much shorter and thinner than the preceding one, in front of which it lies, is attached by its base to the side of the sacrum and coccyx, where its fibres are blended with

those of the great ligament; and, by its apex, to the spine of the ischium. Its form is triangular, and the direction of its fibres is forwards and outwards.

Fig. 137.

Fig. 137.—Ligaments of the Pelvis and Hip-Joint, as seen from behind in the erect attitude of the Body, from a Female subject. ¼

1, ilio-lumbar ligament: above it the last lumbar intertransverse ligament; 2, posterior sacro-iliac ligaments, the short and the oblique; 3, great sacro-sciatic ligament; 4, attachment of the lesser sacro-sciatic ligament to the spinous process; 5, obturator membrane or ligament; 6, posterior ligament of symphysis pubis; 7, 7, continuation of supraspinous ligaments from the lower lumbar vertebræ over the sacral spines; 8, transverse process of last lumbar vertebra, to which from above is seen descending the last intertransverse ligament, and from below ascending the sacro-vertebral ligament; 9, posterior surface of the capsular ligament of the hip-joint. The posterior ligaments passing between the sacrum and coccyx are also partially shown.

Foramina. Between the upper border of the great sacro-sciatic ligament and the innominate bone is a large space subdivided by the small sacro-sciatic ligament. The part which lies above this ligament is a large oval opening, named the *great sacro-sciatic foramen.* It transmits the pyriform muscle, the great sciatic nerve, and the gluteal and ischiatic vessels and nerves. The part between the greater and lesser sacro-sciatic ligaments, much smaller in size, and bounded in front by the smooth surface between the spine and tuberosity of the ischium, is the *small sacro-sciatic foramen,* through which pass the obturator internus muscle and the internal pudic vessels and nerve.

The PUBIC ARTICULATION, or *symphysis pubis,* is the connection of the pubic bones in front, and is effected by fibro-cartilaginous plates and ligaments. The adjacent surfaces of bone are each coated with cartilage, and to this is attached the fibro-cartilage which unites them. The *fibro-cartilage* is thicker and stronger in front than behind, and generally contains a synovial cavity towards the back part of the joint. The ligaments are named *anterior, posterior, superior,* and *inferior.* The anterior pubic ligament consists of irregular fibres passing obliquely across from bone to bone in front of the symphysis. The superior and posterior ligaments consist of only a few fibres

on the upper and back part of the articulation. The inferior or sub-pubic ligament, thick and triangular, is attached to the rami of the pubic bones, gives

Fig. 138.

Fig. 138.—Right half of a Female Pelvis, seen from the inner side. An opening has been made into the Acetabulum to show the tightened condition of the Round Ligament with the Femur partially flexed and adducted. ⅔

1, supraspinous ligaments descending to the sacrum from 2, 2, the lumbar spinous processes; 3, 4, the lumbar and sacral spinal canal, with its periosteal lining; 5, placed on the ilium above the anterior sacro-iliac ligament; 6, placed in the great sacro-sciatic foramen, points to the lesser sacro-sciatic ligament; 7, greater sacro-sciatic ligament, with 7′, its continuation over the inner border of the tuberosity of the ischium; 8, a portion of the wall of the cotyloid cavity, removed so as to give a view from the inside of the head of the femur, 9, with the round ligament put upon the stretch, the femur being partially flexed and adducted; 10, the inner part of the capsular ligament relaxed; 11, the shaft of the femur.

smoothness and roundness to the upper part of the sub-pubic arch, and forms part of the outlet of the pelvis.

The *obturator membrane* or *ligament* is a fibrous septum attached to the border of the thyroid foramen, which it closes in its entire extent, except at the upper and outer part of its circumference, where a small oval canal is left for the obturator vessels and nerve. The membrane is fixed accurately to the bony margin at the upper and outer sides of the foramen, and to the posterior surface at the inner side. The obturator muscles are attached to its surfaces.

Movements.—In ordinary circumstances there is very little movement allowed between the bones of the pelvis. In the erect posture the sacrum is thrown so much backwards that none of the advantage of the key-stone of an arch is obtained by the tapering of its form from base to apex. It is only by the sinuosities of its auricular surfaces that it directly presses on the hip-bones; and as the width of the bone rather diminishes at the upper or ligamentous part, the principal strain is borne by the posterior sacro-iliac ligaments, from which the sacrum is in great measure suspended (see fig. 139) as is well illustrated by the giving way and bending inwards and downwards of their iliac points of attachment in rickety deformities of the pelvis. Thus the structure of the sacro-iliac articulation gives elasticity. The small amount of movement which is allowed between the bones of the pelvis in the ordinary state is increased during parturition in this way, that the lower part of the sacrum being pressed backwards, the wider part of the edge formed by this bone is forced farther between the ossa innominata, so as to separate them to a greater degree, and thus to increase the capacity of the pelvis. In some subjects it would appear that in pregnant women a slight amount of separation may occasionally occur at the symphysis from the extreme looseness of the connecting parts; but in general it is more probable that the only motion at the symphysis is the hinge-like movement of the ossa innominata just described, and that the cavity of the pelvis owes the principal increase of its dimensions in parturition to the same cause. (See

Wood, article "Pelvis" in "Cyclopæd. of Anat. and Physiol;" Zaglas, in "Monthly Journ. of Med. Science," 1851; J. M. Duncan, in "Dublin Quart. Journ. of Med. Science," 1854, and "Edin. Med. Journ.," 1855.)

ARTICULATIONS OF THE LOWER LIMB.

THE HIP-JOINT.

This is a large ball-and-socket joint, in which the globular head of the femur is received into the acetabulum or cotyloid cavity of the innominate

Fig. 139.

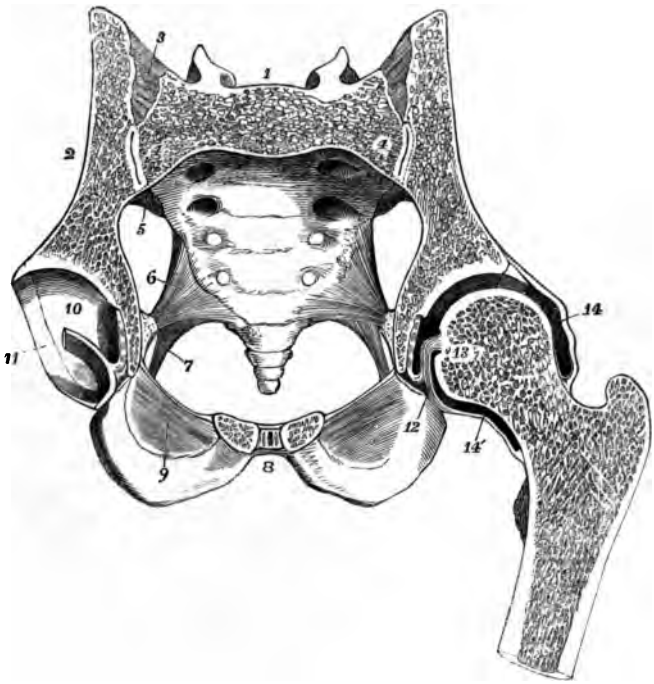


Fig. 139.—TRANSVERSE OBLIQUE SECTION OF THE PELVIS AND HIP-JOINT, CUTTING THE FIRST SACRAL VERTEBRA AND THE SYMPHYSIS PUBIS IN THEIR MIDDLE, FROM A MALE SUBJECT OF ABOUT NINETEEN YEARS OF AGE. ½

1, placed above the middle of the cut surface of the first sacral vertebra, and between the divided superior articular processes; 2, the divided ilium; 3, the posterior sacro-iliac ligaments also divided; 4, 4, the sacro-iliac synchondrosis, with a slight separation between the two plates of cartilage; 5, the anterior sacro-iliac ligament; 6, the anterior or short sacro-sciatic ligament; 7, a portion of the posterior or long sacro-sciatic ligament; 8, placed in front of the symphysis pubis, in the cut surface of which the small median cavity, the adjacent fibro-cartilaginous plates and the anterior and posterior ligamentous fibres are shown; 9, the lower part of the obturator membrane; 10, placed on the cartilaginous surface of the cotyloid cavity of the right side, through the middle of which the incision passes transversely and divides the round ligament and the synovial fat of the depression; 11, the cotyloid ligament or fibrous border; 12, the round ligament of the left side, where it is connected with the transverse part of the cotyloid ligament; 13, placed on the cut surface of the head of the left femur near the depression where the round ligament is attached; 14, 14', the upper and lower parts of the capsular ligament and synovial capsule.

bone. The articulating surface of the acetabulum is formed by a broad riband-shaped cartilage occupying the upper and outer part, and folded round a depression which, extending from the notch, is hollowed out in the bottom of the cavity, and is occupied by delicate adipose tissue covered with synovial membrane, the so-called synovial or Haversian gland. The articulating surface of the femur presents a little beneath its centre a pit in which the round ligament is attached.

The *cotyloid ligament* forms a thick ring round the margin of the acetabulum, increasing the depth of its cavity, and bridging over the deficiency in its border. Its external surface is in contact with the capsular ligament, the internal closely embraces the head of the femur, and both are covered by the synovial membrane. Its fibres do not run parallel to the circumference of the cotyloid cavity, but pass obliquely from without inwards over its margin, one extremity being attached to the outer, the other to the inner surface.

At the cotyloid notch the fibres of the ligament are continued from side to side, so as to render the circumference complete, and deeper transverse fibres are superadded, from which circumstance, as well as from being stretched across from one margin of the notch to the other, this part is called the *transverse ligament.* Subjacent to it an interval is left for the admission of the articular vessels.

The *interarticular* or *round ligament* (ligamentum teres) is a strong fasciculus surrounded by synovial membrane, implanted by one extremity, which is round, into the fossa in the head of the femur; by the other, which is broad, flat, and bifid, into the margins of the cotyloid notch, where its fibres become blended with those of the transverse ligament. It rests on the fat in the depression of the acetabulum.

The *capsular ligament,* surrounding the joint, is attached superiorly in the greater part of its extent to the acetabulum, within two or three lines from the cotyloid ligament, except at the notch, where it is connected with the transverse ligament. At its femoral border it extends in front as far as the anterior intertrochanteric line, but behind it falls short considerably of the posterior intertrochanteric ridge. Its strongest part is in front, and there its fibres extend vertically from the upper part of the acetabulum to the lower part of the intertrochanteric line, and are strengthened by a firm fasciculus, descending from the anterior inferior spine of the ilium, called the *accessory* or *ilio-femoral ligament.* On its superior border the capsule is strengthened by fibres connected with the insertion of the gluteus minimus muscle. The fibres which arise in front of the notch of the acetabulum pass down in front of the small trochanter; those which arise behind the notch pass towards the trochanteric fossa; and between those two fasciculi, the capsule is extremely weak, and its fibres pass in a circular direction, so that opposite the posterior intertrochanteric ridge no fibres are inserted into the neck of the femur, and the reflection of the synovial membrane from the bone to the capsule can be laid bare behind the neck without cutting any part of the capsule.

The *synovial membrane* lining the joint and ligament is reflected from the neck of the femur to the inner surface of the capsule; passing over the inner surface of the capsule to the margin of the acetabulum, it is reflected from that and from the synovial fat as a tubular investment of the round ligament to the head of the femur.

Movements.—In the hip-joint movement is allowed in every direction. Extension is limited by the capsular ligament, the anterior fibres of which become tense in that

position: flexion is limited only by the contact of the neck of the femur with the acetabulum. The round ligament is put upon the stretch when the thigh is partially flexed and adducted; it therefore resists dislocation upwards and backwards on the dorsum ilii, which is, notwithstanding its presence, the most frequent kind of displacement. The round ligament is also put upon the stretch in the position of flexion and external rotation.

THE KNEE-JOINT.

The articular surfaces of this complicated joint are the condyles of the femur and tibia, with fibro-cartilages interposed, the articulating surface of the patella, and the patellar surface of the femur. The action is mainly that of a hinge-joint. The joint is strengthened superficially by fibrous coverings

Fig. 140.

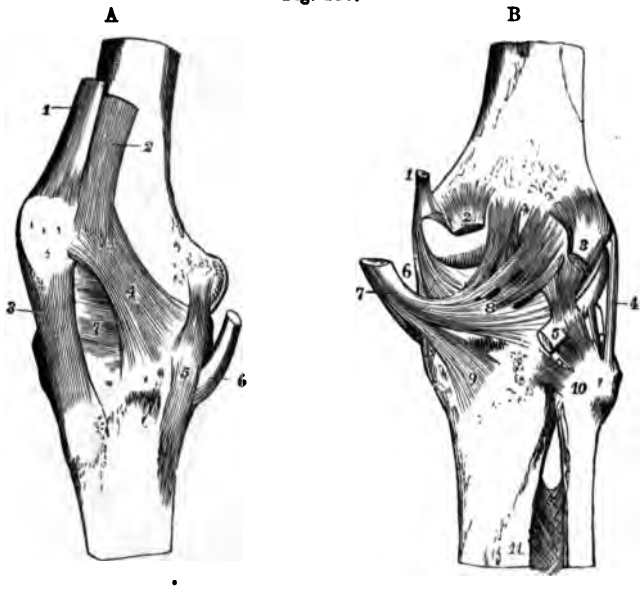


Fig. 140, A.—RIGHT KNEE-JOINT, FROM THE INSIDE AND ANTERIORLY. ½

1, tendon of the rectus muscle near its insertion into the patella; 2, insertion of the vastus internus into the rectus tendon and side of the patella; 3, ligamentum patellæ descending to the anterior tuberosity of the tibia; 4, capsular fibres forming a lateral ligament of the patella prolonged in part from the insertion of the vastus internus downwards towards the inner tuberosity of the tibia; 5, internal lateral ligament of the knee-joint seen spreading on the internal semilunar cartilage; 6, tendon of the semimembranosus muscle (after Arnold).

Fig. 140, B.—KNEE-JOINT FROM BEHIND.

1, insertion of the tendon of adductor magnus; 2, origin of the inner head of the gastrocnemius muscle; 3, outer head of the same; 4, cord-like external lateral ligament; 5, tendon of the popliteus muscle: a ligament descending from behind the outer condyle of the femur is seen attached to this tendon below, and another descending from the tendon is attached to the head of the fibula, constituting the short external lateral ligament; 6, part of internal lateral ligament; 7, tendon of the semimembranosus muscle; 8, posterior ligament of Winslow, spreading outwards from the tendon; 9, expansion of the popliteal fascia downwards from the same, represented as cut short; 10, on the head of fibula, marks the posterior superior tibio-fibular ligament; 11, upper part of the interosseous ligament, with the foramen above it for the anterior tibial artery.

derived from the muscular tendons and aponeuroses. The ligaments which have received special names are the following :—

The *internal lateral ligament*, long and flat, connects the internal tuberosity of the femur with the inner tuberosity and the hinder border of the tibia, on the shaft of which it descends for some distance. Superiorly its deep surface rests on the articular synovial membrane ; below the head of the tibia the anterior slip of insertion of the semimembranosus muscle passes between the ligament and the bone.

The *external lateral ligament* is a rounded cord, which extends from the external tuberosity of the femur to the head of the fibula. Its internal surface corresponds with the tendon of the popliteus muscle and the inferior external articular vessels. The tendon of the biceps flexor cruris muscle

Fig. 141.

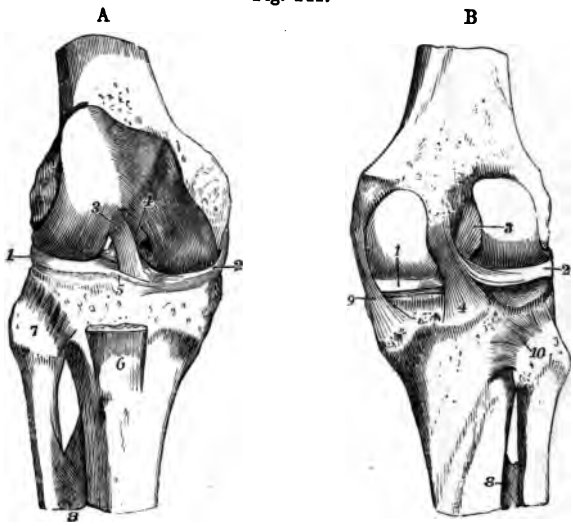


Fig. 141, A.—THE KNEE-JOINT, OPENED FROM BEFORE ; THE PATELLA, CAPSULE, AND SYNOVIAL STRUCTURES REMOVED, TO SHOW THE CRUCIAL LIGAMENTS AND SEMILUNAR CARTILAGES. ½

1, external, and 2, internal semilunar cartilage ; 3, on the outer condyloid surface of the femur, points to the anterior external crucial ligament ; 4, placed on the elevated line separating the patellar from the inner condyloid surface of the femur, points to the posterior or internal crucial ligament ; 5, transverse ligament of the semilunar cartilages ; 6, part of the ligamentum patellæ ; 7, on the head of the fibula, points to the superior anteror tibio-fibular ligament ; 8, upper part of the interosseous membrane, showing the perforation for the anterior tibial artery.

Fig. 141, B.—THE KNEE-JOINT, OPENED FROM BEHIND, AND ITS STRUCTURES REMOVED, SO AS TO EXPOSE THE CRUCIAL LIGAMENTS AND SEMILUNAR CARTILAGES. ½

1, posterior part of the internal semilunar cartilage ; 2, external semilunar cartilage ; 3, upper part of the external or anterior crucial ligament ; 4, lower part of the internal or posterior crucial ligament : farther up is seen its accessory band joining the external semilunar cartilage ; 8, upper part of the interosseous membrane ; 9, back part of the internal lateral ligament ; 10, placed on the head of the fibula, points to the posterior superior tibio-fibular ligament : between the head of the fibula and the external semilunar cartilage (2) is seen the synovial surface of the tibia, upon which the semilunar cartilage descends in flexion, and where a communication sometimes takes place between the synovial cavities of the knee-joint and the tibio-fibular articulation.

is frequently divided into two by this ligament, and between the ligament and the tendon there is a synovial bursa. Further back is another band, the *short external lateral ligament*, the arrangement of which is more variable, often connected with the tendon of the popliteus muscle, and occasionally terminating in the capsular membrane.

The *posterior ligament* is a flat fasciculus of fibres passing from behind the inner tuberosity of the tibia upwards and outwards to the external condyle of the femur, and is in part continuous at its inner end with the tendon of the semi-membranosus muscle.

The *ligamentum patellæ* is a strong flat band, of a tendinous nature, attached superiorly to the lower extremity of the patella, and the depression beneath its articular surface, and inferiorly to the anterior tubercle of the tibia. Between the tibia and the ligament, near its insertion, is placed a synovial bursa. If the patella be considered a sesamoid bone, this ligament may be regarded as part of the tendon of the rectus femoris muscle.

The *crucial ligaments*, placed in the centre of the joint, pass from the sides of the intercondyloid fossa to the spaces in front of and behind the spine of the tibia. They decussate somewhat like the lines of the letter X. The *anterior* or *external ligament* is fixed by its lower extremity to the inner part of the pit before the spine of the tibia, and by its upper extremity it is inserted into the inner and hinder part of the external condyle of the femur; hence its direction is upwards, backwards, and outwards. The *posterior* or *internal ligament* is attached inferiorly to the back of the pit behind the tibial spine, and superiorly to the fore part of the intercondyloid hollow, as well as slightly to the side of the inner condyle of the femur; its fibres are directed upwards and a little forwards.

The *semilunar cartilages* are two crescent-shaped inter-articular fibro-cartilages, placed on the articulating surfaces of the head of the tibia, and interposed between these and the condyles of the femur. They have each a synovial surface above and below, and a convex border, which is thick, while the concave border is thinned to a fine edge, and the part of the articular surface of the tibia within the concave border of each cartilage is left uncovered. At their extremities they are fibrous, and are firmly fixed to the head of the tibia, whilst by the circumference they are connected with the fibrous capsule of the joint.

Fig. 142.

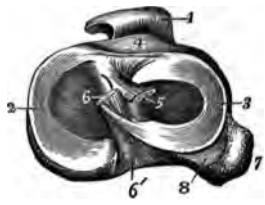


Fig. 142.—View of the Interarticular Fibro-Cartilages of the right Knee-joint, from above, as they lie on the upper surface of the Tibia, with the Crucial Ligaments divided, and the Ligamentum Patellæ turned forwards. ½

1, ligamentum patellæ; 2, the inner, or semicircular fibro-cartilage; 3, the outer, or nearly circular one; 4, is placed above the anterior tuberosity of the tibia in front of the transverse ligament; 5, the cut end of the anterior crucial ligament directed obliquely towards the outer side and backwards; 6, the cut end of the posterior crucial ligament, from which fibres are seen descending to the outer fibro-cartilage; 6′, tibial attachment of the posterior crucial ligament; 7, the head of the fibula; 8, the synovial surface of the tibia, which extends for some way downwards towards the tibio-fibular synovial sac, with which it is sometimes continuous.

The *internal semilunar cartilage*, elongated from before backwards, is nearly of a semicircular form: its anterior cornu is small and pointed, and is inserted into an impression at the fore and outer part of the internal articular surface of the tibia; its posterior end is attached to the inner

edge of the hollow behind the spine, and is in relation with the posterior crucial ligament.

The *external semilunar cartilage* forms nearly a complete circle ; its two cornua, fixed, one before, the other between the points of the spine of the tibia, are so close at their insertion that they may be said to be interposed between the attachments of the internal semilunar plate. Its external border is in contact behind with the tendon of the popliteus muscle, and is therefore separated by this from the fibrous capsule. From this fibro-cartilage a ligamentous band ascends, to be attached to the inner condyle of the femur in connection either in front or behind with the posterior crucial ligament (*accessory band of the posterior crucial ligament*).

Transverse ligament.—Towards the front of the joint the convex borders of the inter-articular fibro-cartilages are connected by a slight transverse band, which receives this name. Its thickness varies much in different bodies.

Capsular membrane.—Under this name is described the fibrous tissue which invests the joint in the intervals between the stronger bands which have been named ligaments. It is incomplete, not extending underneath the tendons of the extensor muscles. Between the sides of the patella and the femur it consists of fibres connected with the insertion of the vasti muscles and with the fascia lata, and thus forms the structures, uniting the patella to the tibia, which have been called *lateral patellar ligaments;* posteriorly it covers the condyles of the femur beneath the gastrocnemius muscle. In this last situation it is thin, and a sesamoid bone is often found in connection with it in the outer, less frequently in the inner head of the muscle.

Fig. 143.

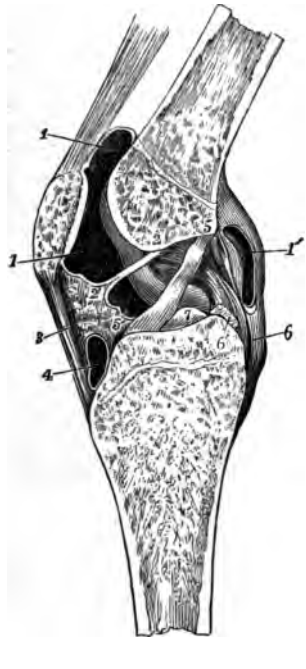


Fig. 143.—Vertical Antero-Posterior Section of the Left Knee-Joint, seen from the outer or left side. ½

The section is made somewhat obliquely a little to the outside of the middle, so as to preserve entire the crucial ligaments with their attachments: it is from a young subject of eighteen or nineteen years. 1, 1, the upper portion of the synovial cavity of the joint, showing in the part above the patella the synovial pouch which extends upwards between the extensor tendons and the femur ; 1′, an aperture made into the posterior portion of the synovial cavity ; 2, 2′, ligamentum mucosum ; 3, ligamentum patellæ ; 2′, 3, the subpatellar synovial fatty cushion ; 4, bursa above the insertion of the ligamentum patellæ into the anterior tibial tuberosity ; 5, 5′, the anterior crucial ligament ; 5′, points also to the internal semilunar cartilage within the joint ; 6, lower part of the posterior crucial ligament, the upper part of which is towards 2 ; 6′, the accessory band joining the external semilunar cartilage, which is cut short ; 7, the spine of the tibia.

The *synovial membrane* is the largest in the body. Traced downwards from the femur on either side of the joint, it may be followed from the capsule to the upper surface of the semi-lunar cartilages, round the free borders of those structures to their inferior surfaces

and thence to the tibia. The crucial ligaments are invested in front by a reflected portion of the membrane continued forwards from the posterior wall of the joint. Between the tibia and patella the synovial membrane lies upon a large pad or cushion of fat, on the surface of which it forms two lateral folds (*alar ligaments*) which fit into the space between the tibia, patella and femur, while from the middle of the pad it sends backwards a cylindrical process, the *ligamentum mucosum*, through the joint to the front of the intercondyloid fossa. Above the patella the synovial membrane extends upwards some distance, forming a large pouch between the extensor tendons and the femur.

Movements, &c.—In order to explain the nature of these movements, it is necessary to state some considerations with regard to the relations of the several parts of the knee-joint to each other. The knee-joint may be regarded as consisting of three articulations conjoined, viz., that between the patella and femur, and two others, one between each condyle of the femur and the tibia. In most mammals the synovial membranes of those three joints are either completely distinct or communicate with each other by only small openings. In the human subject the ligamentum mucosum is an indication of the original distinctness of the synovial membranes of the inner and outer joint, and the crucial ligaments may be looked upon as the external and internal lateral ligaments of those two joints respectively. Each portion of the articular surface of the femur belongs either to one or other of the three component joints of the knee, and no part is common to any two of them. On a well-marked

Fig. 144.

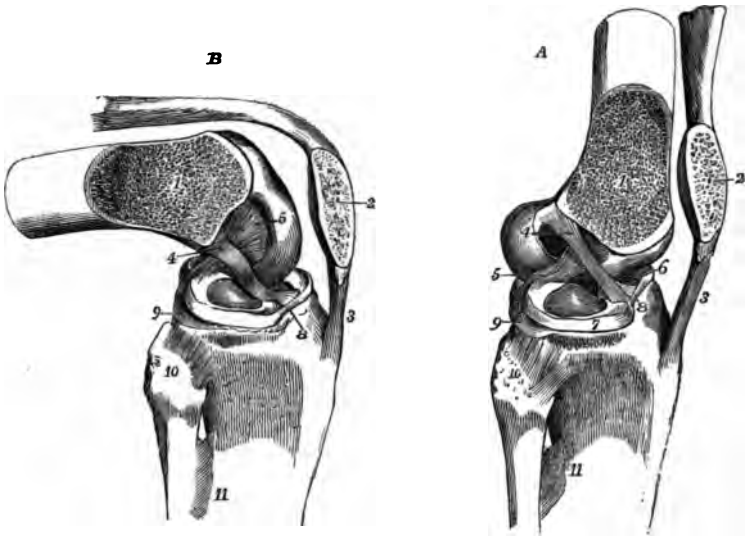


Fig. 144.—The superficial parts of the Knee-joint removed, and the external Condyle of the Femur sawn off obliquely, together with half the patella, so as to expose both the crucial ligaments together. ½

In A, the parts are in the position of extension, in B, that of flexion, the figures being designed to show the different state of tension of the crucial ligaments in these positions. 1, sawn surface of the femur; 2, sawn surface of the patella; 3, ligamentum patellæ; 4, anterior or external crucial ligament, tense in A, and relaxed in B; 5, posterior or internal crucial ligament, relaxed in A, tense in B; 6, internal, and 7, external semilunar cartilage; 8, transverse ligament; 9, articular surface of the tibia, extending behind the external semilunar cartilage; 10, on the head of the fibula, points to the anterior superior tibio-peroneal ligament; 11, upper part of the interosseous membrane.

femur, the inferior limits of the patellar surface are quite distinguishable; the line which separates this surface from the outer tibial joint passing directly between it and the condyle, and that which separates it from the inner joint being continued backwards, so as to cut off from the rest of the inner condyle a narrow tract at the side of the inter-condyloid fossa.

The movement of the patella on the femur is one partly of gliding, partly of coaptation. This is illustrated by a careful examination of the articular surface of the patella, which is not uniformly curved from above downwards, as it would be, were the movement one of gliding only, but exhibits on each side of the vertical ridge three very slightly depressed surfaces, separated by two slight transverse elevations, and along the inner margin a seventh area, upon which the transverse lines do not encroach (Goodsir). When the knee is extended, and the patella drawn upwards by the extensor muscles, the two inferior facets of the patella are in contact with the upper margin of the femoral surface; in semiflexion the middle facets only are in contact with the femur; in greater flexion, the superior parts of the patella are in contact with the lower part of the femoral surface; and in extreme flexion the patella, which has been gradually turned outwards by the increasing prominence of the inner condyle, rests by its innermost facet on the inter-condyloid margin of that condyle. If the condyles of the femur be examined as they rest upon the tibia in the flexed position of the joint, it will be seen that the inner condyle is more elongated than the outer, and that the portion of the inner condyle which lies in front of the anterior limit of the external condyle inclines obliquely outwards, to reach the patellar surface. In the movement of extension the condyles move parallel to one another, until complete extension is nearly reached, and then, the anterior part of the rolling surface of the external condyle having already come in contact with the tibia, the inner condyle continues to glide backwards, and brings its oblique anterior part into contact with the tibia, so that the bone is rotated inwards on the tibia, and over-extension is prevented, not merely by the tightness of the ligaments, but by the femur being pressed up against the tibial spine. In complete extension the lateral ligaments and the external crucial ligament are tight, while the posterior crucial ligament is relaxed; in flexion the external lateral and external crucial ligaments become relaxed, and the posterior crucial ligament is tightened. In extension of the joint no rotation of the leg is possible; in the flexed condition a considerable amount is allowed. When the weight of the body keeps the bones in their position in the extended knee, the extensor muscles are relaxed, the patella drops down from its position in contact with the femur, and the ligamentum mucosum then comes into play, supporting the synovial membrane and fat below the patella. (See Meyer, op. cit.; Goodsir, in "Edin. Med. Journ.," 1855, and "Proceedings of Roy. Soc. of Edin.," 1858; Langer, "Sitzungsber. d. Acad. der Wissensch. Wien," 1858; Henke, "Zeitschr. für rat. Med.," v. viii., 1859.)

ARTICULATIONS OF THE LEG AND ANKLE.

PERONEO-TIBIAL ARTICULATIONS.—The tibia and fibula are connected at their upper and lower extremities by synovial articulation, and their shafts are united by an interosseous membrane.

The *superior extremities* of the bones present two flat oval articular surfaces, retained in close contact by an *anterior* and a *posterior superior tibio-fibular ligament*, both of which pass upwards and inwards from the head of the fibula to the external tuberosity of the tibia. The synovial membrane which lines this joint not unfrequently communicates posteriorly with that of the knee.

The *interosseous membrane* or *ligament*, which connects the shafts of the tibia and fibula, passes between the external ridge of the tibia and the ridge on the inner surface of the fibula, and is composed for the most part of parallel fibres running outwards and downwards, only a few fibres crossing them in a different direction. The membrane is broader above than below, and presents superiorly an elongated opening for the transmission of the anterior tibial vessels, and inferiorly a small aperture for the passage of the anterior branches of the peroneal vessels.

The *inferior extremities* of the tibia and fibula are in contact by surfaces which for the most part are rough and bound together by ligament, but near

Fig. 145.—Articulations of the Knee, Leg and Ankle, seen from before. $\frac{1}{3}$

1, superior anterior tibio-fibular ligament; 2, interosseous membrane; 3, points to the anterior inferior tibio-fibular ligament; 4, internal lateral ligament of the ankle-joint; 5, middle vertical part (calcaneo-fibular) of the external lateral ligament of the ankle-joint; 6, anterior part (talo-fibular) of the same; 7, anterior ligament of the ankle-joint.

Fig. 145.

their lower edges are smooth and covered by cartilage. The tibial surface is concave, the fibular convex; but the lower edges of both surfaces are straight. The strong short fibres which pass directly between the opposing surfaces form the *inferior interosseous ligament.* The *anterior ligament* is a flat band of fibres, extended obliquely over the lower part of the bones, the direction of its fibres being downwards from the tibia to the fibula. The *posterior ligament,* somewhat triangular, is similarly disposed behind the articulation; its outer surface is covered by the peronei muscles. The *transverse ligament,* longer and narrower than the preceding, is placed immediately below it; its fibres are horizontal, and extend from the external malleolus to the contiguous part and hinder border of the articular surface of the tibia; it closes the interval between the bones.

The *synovial cavity* lying between the small articular surfaces is an extension of that of the ankle-joint.

The Ankle-Joint.—In this articulation, which is a hinge joint, the inferior extremities of the tibia and fibula, united so as to form a kind of arch, embrace transversely the superior articular surface of the astragalus, so as to render lateral movement impossible when the ligaments are tense.

Fig. 146.—The Lower Tibio-Fibular Articulation and Ankle-Joint, from behind.

1, inferior posterior tibio-fibular ligament; 2, transverse ligament; 3, posterior fibres of the internal lateral ligament of the ankle-joint; 4, middle, and 5, posterior part of the external lateral ligament of the ankle-joint; 6, posterior talo-calcaneal ligament.

Fig. 146.

The *internal lateral ligament* is a flat fasciculus of fibres, much broader at the lower than at the upper part. One extremity is attached to the inferior border of the internal malleolus; the other, to the inner side of the astragalus, the os calcis, and the scaphoid bone, as well as to the inferior calcaneo-scaphoid ligament.

The *external lateral ligament* consists of three distinct bands, separated by intervals and disposed in different directions. 1. The middle band descends from the extremity of the fibula, and is inserted into the middle of the external surface of the os calcis. 2. The anterior band passes obliquely

forwards and inwards from the fore part of the outer malleolus to a part of the astragalus in front of its external malleolar surface; it is the shortest of the three. 3. The posterior band, the strongest of the three, passes almost horizontally inwards from the pit on the inner and back part of the malleolus to the posterior surface of the astragalus.

Fig. 147.

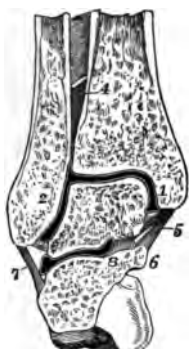


Fig. 147.—Transverse-Vertical Section of the Right Ankle-Joint near its Middle, and of the Posterior Talo-Calcaneal Articulation, so as to show the Shape of the Articular Surfaces and Cavities, viewed from before. ½

1, internal, 2, external malleolus; 3, placed on the astragalus at the angle between its superior and its external malleolar surfaces; 4, points to the interosseous tibio-fibular ligament; 5, internal lateral ligament of the ankle-joint; 6, sustentaculum tali; 7, calcaneo-fibular or middle part of the external lateral ligament; 8, inner part of the interosseous calcaneo-talar ligament; 9, great tuberosity of the calcaneum: between the tibia, fibula and astragalus, the synovial cavity is indicated by the dark space enclosed by a white line; between the astragalus and os calcis a section of the posterior calcaneo-talar synovial cavity is shown.

The *anterior* and *posterior ligaments* are merely scattered fibres in front of and behind the joint; those of the posterior ligament are weak and principally transverse.

The *synovial membrane* of the ankle-joint extends upwards by a small process which lines the inferior peroneo-tibial articulation.

Movements.—The movements at the ankle-joint are mainly those of flexion and extension of the foot, and the directions of those movements are principally determined by the shape of the articular surfaces. The external border of the superior cartilaginous surface of the astragalus is curved, and longer than the internal border, and hence extension of the ankle-joint is accompanied with a slight inward movement of the toes. The horizontal surfaces of both the tibia and astragalus are broader in front than behind; hence in complete extension of the ankle the narrow part of the astragalus is brought into the widest part of the space between the malleoli, and a certain amount of lateral motion is allowed, whereas in complete flexion, as when the weight of the body, with completely bended knees, is supported on the toes, the broad part of the surface of the astragalus is pushed back into the narrowest part of the space, and the inferior extremity of the fibula is pressed upon, so as to stretch the ligaments between it and the tibia, and give a certain amount of spring to the joint. There appears to be no other movement between the tibia and fibula; these bones being bound together at their lower ends with remarkable firmness.

ARTICULATIONS OF THE FOOT.

Articulations of the Calcaneum, Astragalus, and Scaphoid Bones one with another.—The astragalus is connected with the calcaneum by two synovial articulations, viz., by a posterior one peculiar to those two bones, and by an anterior one common to them with the scaphoid bone. The following are the principal parts requiring description:—

Astragalo-calcaneal ligaments.—The *interosseous ligament*, broad and strong, passes vertically downwards from the groove between the anterior and posterior articular surfaces of the astragalus to the similar groove between the corresponding articular surfaces of the calcaneum. A membranous *posterior ligament* connects the posterior border of the astragalus with the upper surface of the calcaneum; its fibres are oblique and very short.

There is also an *external ligament*, consisting of a slight fasciculus of fibres, which descends perpendicularly from the outer surface of the astragalus to the external side of the calcaneum, parallel with the middle division of the external lateral ligament of the ankle-joint. It may be farther observed, that those portions of the lateral ligaments of the ankle-joint which pass down over the astragalus to the os calcis assist in uniting these two bones.

Calcaneo-scaphoid ligaments.—The calcaneum and scaphoid bone are not in contact, but they are connected by two ligaments. The *inferior* or *plantar* ligament, much the larger of the two, is a broad band which passes forwards and inwards from the fore-part of the calcaneum (sustentaculum tali) to the inferior surface of the scaphoid bone. It is in contact inferiorly with the tendon of the tibialis posticus muscle, while superiorly it forms the floor of the articular cavity which receives the head of the astragalus, and is lined by synovial membrane. The *external, dorsal,* or *inter-osseous ligament,* forms the external boundary of the cavity just mentioned, and lies deeply at the anterior part of the fossa (sinus pedis), between the astragalus and os calcis. Its fibres, very short, are directed from behind forwards between the contiguous extremities of the bones. They are attached posteriorly to a ridge of the os calcis that separates the articular surfaces for the astragalus and os cuboides, and anteriorly to the outer side of the scaphoid bone.

Fig. 148.

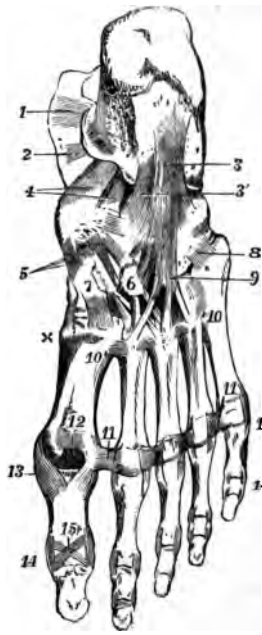


Fig. 148.—LIGAMENTS OF THE FOOT, SEEN FROM BELOW. ½

1 and 2, portions of the internal lateral ligament of the ankle joint descending upon the calcaneum ; 3, calcaneo-cuboid or long plantar ligament; 3', deep or short part of the same; 4, plantar calcaneo-scaphoid ligament ; 5, three scaphoido-cuneiform ligaments of the internal, middle and external cuneiform bones ; 6, is placed upon the external cuneiform bone towards which is seen coming from behind a cuboido-cuneiform ligament; 7, is placed upon the internal cuneiform bone ; from 6 and 7, are seen passing downwards the plantar cuneo-metatarsal ligaments; ×, part of the first dorsal cuneo-metatarsal ligament ; 8 and 9, ligamentous fibres prolonged from the cuboid bone and sheath of the peroneus longus muscle upon the outer metatarsal bones ; 10, 10, between these figures the posterior intermetatarsal (or transverse) ligaments ; 11, 11, anterior transverse metatarsal ligament, continued across the four metatarsal spaces ; 12, intersesamoid ligament; 13, 13, between these figures are seen the five pairs of internal and external lateral metatarso-digital ligaments; 14, 14, between these figures are seen the five pairs of internal and external lateral digital (phalangeal) ligaments of the first series : those of the second series have no figure placed to mark them ; 15, inferior ligament of the phalangeal articulation of the great toe.

The *talo-scaphoid* or *astragalo-scaphoid ligament,* a membranous band of fibres situated on the dorsum of the foot, extends obliquely forwards from the anterior extremity of the astragalus to the superior surface of the scaphoid bone, and completes the capsule of the calcaneo-talo-scaphoid joint, formed in the rest of its extent by the plantar and external calcaneo-scaphoid ligaments.

One *synovial membrane* lines the calcaneo-talar joint, and another the calcaneo-talo-scaphoid articulation.

CALCANEO-CUBOID ARTICULATION. — The calcaneum is united to the cuboid bone by a synovial joint and ligaments.

The *inferior ligament* consists of two distinct fasciculi of fibres, differing in form and attachments ; of which one is superficial the other deep-seated. The superficial part, called the *long plantar ligament*, is the longest of the tarsal ligaments. Its fibres, attached behind to the inferior surface of the calcaneum as far as the anterior tubercle, pass forwards, and are attached in greater part to the tuberosity on the under surface of the cuboid bone ; some of them are continued onwards, and terminate at the bases of the third and fourth metatarsal bones, after covering the tendon of the peroneus longus muscle. The *short* or *deep-seated plantar calcaneo-cuboid ligament* lies close to the bones, being separated from the superficial part by some cellular tissue. Its breadth is considerable, its length scarcely an inch. One extremity is attached to the calcaneum in front of the long ligament, the other (somewhat expanded) to the under surface of the cuboid bone, internal to the tuberosity.

The *dorsal* or *superior ligament* is a flat band of fibres which connects the anterior and upper surface of the calcaneum with the adjacent part of the cuboid bone.

The *internal* or *interosseous ligament* is placed deeply in the hollow between the astragalus and os calcis, and is closely connected with the external calcaneo-scaphoid ligament.

Fig. 149.

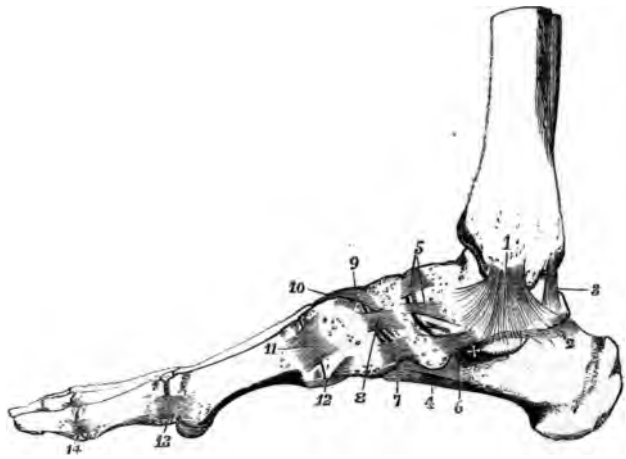


Fig. 149.—LIGAMENTS OF THE FOOT, FROM THE INNER SIDE. ½

1, internal lateral ligament of the ankle; ×, in front of the sustentaculum tali, showing part of the internal lateral ligament descending upon it; 2, posterior talo-calcaneal ligament ; 3, posterior ligament of the ankle-joint ; 4, part of the long and short calcaneo-cuboid ligaments seen from the inside ; 5, two superior astragalo-scaphoid or talo-scaphoid ligaments; 6, internal talo-scaphoid ligament; 7, internal scaphoido-cuneiform (first); 8, dorsal or superior cuneiform ; 9, scaphoido-cuneiform (second); 10, intercuneiform, or transverse dorsal cuneiform, between the first and second cuneiform bones ; 11, internal or first tarso-metatarsal ligament ; 12, inferior first tarso-metatarsal ; 13, internal lateral metatarso-digital : the internal sesamoid bone is seen below; 14, internal lateral digital ligament (of the first toe) : those of the second toe are also seen beyond.

A separate *synovial membrane* lines this joint.

ARTICULATIONS OF THE SCAPHOID, CUBOID, AND CUNEIFORM BONES, ONE WITH ANOTHER.—The *scaphoid* and *cuboid bones* are connected by a *dorsal ligament*, composed of short thin fibres, extended obliquely between the two bones; a *plantar*, situated in the sole of the foot, and consisting of transverse fibres; and an *interosseous ligament*, which intervenes between the bones, and is attached to their contiguous surfaces. When the bones touch, which is not always the case, they present two small articulating surfaces, which are covered with cartilage, and have between them an offset of the adjacent synovial membrane.

The *scaphoid* and the *cuneiform bones* are held together by dorsal ligaments. It will be recollected that the scaphoid bone articulates with the three cuneiform by the smooth faces on its anterior surface. The *dorsal ligaments*, three in number, pass from the upper surface of the scaphoid to the first, second, and third cuneiform bones, into which they are inserted. *Plantar bands* are similarly disposed on the under surface of the bones, but these are continuous with, or offsets from, the tendon of the tibialis posticus muscle.

The *cuboid* and the *external cuneiform bones* are connected by a *dorsal*

Fig. 150.

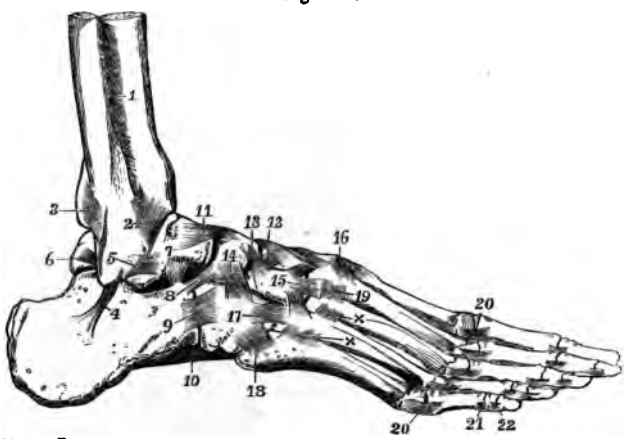


Fig. 150.—LIGAMENTS OF THE FOOT, FROM THE OUTSIDE AND DORSAL ASPECT. ½

1, lower part of the interosseous membrane; 2, lower anterior tibio-peroneal ligament; 3, lower posterior tibio-peroneal ligament; 4, middle part of the external lateral ligament of the ankle-joint, passing to the calcaneum; 5, anterior part of the external lateral ligament of the ankle-joint, passing to the astragalus; below the last ligament the external calcaneo-talar ligament has not been represented in this figure; 6, posterior part of the external lateral ligament of the ankle-joint, passing to the astragalus; 7, is placed above the interosseous calcaneo-talar ligament; 8, dorsal calcaneo-scaphoid; 9, dorsal calcaneo-cuboid; 10, part of the long plantar or calcaneo-cuboid; 11, superior talo-scaphoid; 12 and 13, second and third scaphoido-cuneiform, and between them one of the intercuneiform ligaments; 14, superior scaphoido-cuboid; 15, placed on the external cuneiform bone, points to the cuneo-metatarsal ligament of the third bone; above and below 15, are corresponding ligaments from the external cuneiform to the second and fourth metatarsal bones; 16, cuneo-metatarsal ligament, from the first cuneiform to the second metatarsal bone; between 12, and 16, are seen the cuneo-metatarsal ligaments which converge from the three cuneiform bones on the second metatarsal; 17, cuboido-metatarsal ligament passing to the fourth metatarsal bone; 18, that to the fifth; 19 and × ×, dorsal intermetatarsal ligaments; 20, lateral metatarso-digital; 21, 22, lateral digital.

ligament, which is a thin fasciculus of fibres extended between them; a *plantar ligament*, whose fibres are transverse and rather indistinct; and a bundle of *interosseous* fibres attached to their neighbouring sides. Between the two bones a distinct articulation is formed by cartilaginous surfaces; it is provided sometimes with a separate synovial membrane, at others with an offset from that which belongs to the scaphoid and cuneiform bones.

The *three cuneiform bones* are connected by transverse *dorsal ligaments* and strong *interosseous* fibres; but the latter are their most efficient uniting structures. A transverse plantar ligament exists only between the two innermost bones. The articulations between these bones are lined by offsets from the synovial membrane of the joint between them and the scaphoid bone.

ARTICULATION OF THE TARSUS WITH THE METATARSUS.—The four anterior bones of the tarsus, viz., the three cuneiform and the cuboid, articulate with the metatarsal bones; and as the first and third cuneiform bones project beyond the middle one, and the third cuneiform beyond the cuboid bone, the anterior surface of the tarsus is very irregular. The first metatarsal bone articulates with the internal cuneiform; the second is wedged in between the first and third cuneiform, and rests against the second; the third metatarsal bone articulates with the extremity of the external cunei-

Fig. 151.

Fig. 151.—THE SYNOVIAL CAVITIES OF THE ANKLE-JOINT AND THE TARSAL AND TARSO-METATARSAL ARTICULATIONS, IN SECTION. ½

The section has been carried obliquely upwards and inwards across the foot, and vertically through the upper part of the astragalus and the tibia. 1, cut surface of the tibia above the ankle-joint; 2, placed on the astragalus above the posterior calcaneo-talar synovial cavity; 3, on the head of the astragalus close to the common calcaneo-talo-scaphoid synovial cavity; 4, interosseous calcaneo-talar ligament; 5, on the anterior edge of the calcaneum, points to the calcaneo-cuboid synovial cavity; 6, interosseous calcaneo-cuboid ligament; 7, on the scaphoid bone, marks the common scaphoido-cuneiform and intercuneiform synovial cavity; 8, on the cuboid bone, points to the interosseous scaphoido-cuboid ligament; 9, internal, 10, middle, 11, external cuneiform bones; 12, cuboid: between these several bones the interosseous ligaments are shown; from 13 to 17, are the metatarsal bones, with the interosseous ligaments between them; 9 to 14, the interosseous ligament from the internal cuneiform to the second metatarsal bone; 11 to 16, the interosseous ligament from the external cuneiform to the fourth metatarsal bone: there are also shown in this figure, the synovial cavity of the first tarso-metatarsal articulation, that between the middle and external cuneiform bones and the second and third metatarsal; and that between the cuboid and the fourth and fifth metatarsal bones.

form ; and the last two with the cuboid bone. The articulations are furnished with synovial membranes, and the bones are held in contact by dorsal, plantar, and interosseous ligaments.

The *dorsal tarso-metatarsal* ligaments are flat, thin bands of parallel fibres, which pass from behind forwards, connecting the contiguous extremities of the bones before mentioned. Thus the first metatarsal bone receives a broad thin band from the corresponding cuneiform bone ; the second receives three, which converge to its upper surface, one passing from each cuneiform bone ; the third has one from the external cuneiform bone ; and, finally, the last two are bound by a fasciculus to each from the cuboid bone, and by fibres from the external cuneiform to the fourth metatarsal bone. The *plantar* ligaments are less regular ; the bands of the first and second toes are more strongly marked than the corresponding ligaments on the dorsal surface ; and those of the fourth and fifth toes, which are merely a few scattered fibres passing to the cuboid, receive support from the sheath of the peroneus longus muscle. Ligamentous bands stretch in an oblique or transverse direction from the internal cuneiform to the second and third metatarsal bones, and from the external cuneiform to the fifth metatarsal.

The *interosseous* ligaments are longitudinal in direction, and have especial interest, because of the resistance which they oppose to the surgeon in separating the metatarsus from the tarsus, in consequence of their deep position between the bones. *a.* The *internal* and largest of these lies to the outer side of the first cuneiform bone, and extends from this bone to the neighbouring side of the second metatarsal, close to the articular surface. *b.* The *external* interosseous ligament separates the articulation of the fourth and fifth metatarsal bones from the rest. It connects the outer side of the external cuneiform bone to the same side of the third, and very strongly to the inner side of the fourth metatarsal. *c.* Occasionally some fibres, of less strength and importance than the preceding, are observable on the outer side of the second metatarsal bone, connecting it to the middle cuneiform.

The interosseous ligaments are found to vary somewhat in their connections from those here stated, being sometimes attached at once to the contiguous sides of two tarsal and two metatarsal bones. Attention was first particularly directed to these ligaments by M. Lisfranc, in connection with the amputation of the foot through the tarso-metatarsal articulation. See "Manuel des Opérations Chirurgicales, &c. Par J. Coster." 3rd edit. Paris, 1829.

Synovial membranes.—There are three synovial membranes in this irregular series of articulations. *a.* One belongs to the internal cuneiform and the first metatarsal bone : the joint formed between these two bones is altogether separate and out of the range of the rest. *b.* A second synovial membrane is placed between the cuboid and the fourth and fifth metatarsal bones ; this is isolated on the inner side by the external interosseous ligament. *c.* The third or middle one is placed between the middle and external cuneiform and the second and third metatarsal bones, and is prolonged between the two last-named bones, as well as sometimes between the third and fourth metatarsal bones. The disposition of this last synovial membrane is subject to variation.

Connection of the Metatarsal Bones with one another.—The metatarsal bones are bound together at their tarsal and digital ends ; very firmly in the former, and loosely in the latter situation.

The tarsal ends or bases of the four outer bones articulate with each other, having lateral cartilaginous surfaces provided with synovial membrane, and

are connected by dorsal, plantar, and interosseous ligaments. The *dorsal* and *plantar* ligaments are short transverse bands stretching across the five metatarsal bones from one to another. The *interosseous* fibres, lying deeply between the bones, occupy the rough parts of their lateral surfaces:

Fig. 152.

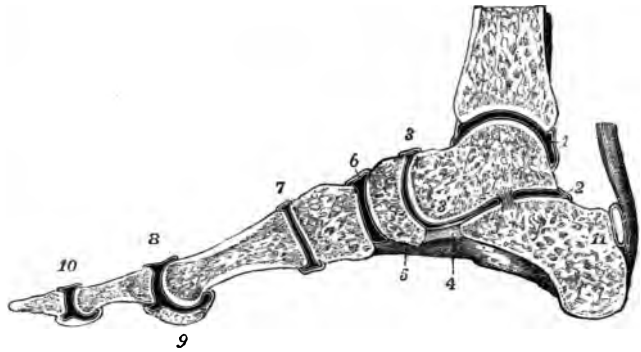


Fig. 152.—VERTICAL ANTERO-POSTERIOR SECTION OF THE ANKLE-JOINT AND ARTICULATIONS OF THE FOOT, A LITTLE TO THE INSIDE OF THE MIDDLE OF THE GREAT TOE OF THE RIGHT FOOT. ½

1, the synovial cavity of the ankle-joint; 2, the posterior talo-calcaneal articulation; 3, placed above the talo-scaphoid articulation; 3′, on the astragalus above the anterior talo-calcaneal articulation, which is continuous with the preceding: the interosseous ligament is seen separating 2 from 3′; 4, the inferior calcaneo-scaphoid ligament; 5, part of the calcaneo-cuboid or long plantar ligament; 6, the scaphoido-cuneiform articulation; 7, the first metatarso-cuneiform articulation; 8, the first metatarso-phalangeal articulation; 9, section of the inner sesamoid bone; 10, the phalangeal articulation; 11, placed on the calcaneum, indicates the bursa between the upper part of the tuberosity of that bone and the tendo Achillis.

they are of considerable strength and firmness. The intermetatarsal articular cavities are lined with *synovial membrane*, which in each is continued forwards from that lining the joints formed between the bases of these bones and the tarsus. The first and second metatarsal bones do not articulate laterally with each other.

Transverse metatarsal ligament.—The digital extremities or heads of the metatarsal bones are loosely connected by a transverse band, which is identical in its arrangement with the corresponding structure in the hand, with this exception, that it is attached to the great toe, whereas in the hand the transverse metatarsal ligament does not reach the thumb.

ARTICULATIONS OF THE METATARSAL BONES WITH THE DIGITAL PHALANGES, AND OF THE LATTER ONE WITH ANOTHER.—The heads of the metatarsal bones are connected with the small concave articular surfaces of the first phalanges by two lateral ligaments, an inferior ligament, and a synovial membrane, which are closely similar to those which belong to the corresponding parts of the hand.

The articulations of the phalanges with one another are also constructed on the same plan as those of the superior extremity. In each, the bones are held in contact by two lateral ligaments and an inferior ligament or fibrous plate; and each of the cavities is lined by a synovial membrane.

MOVEMENTS, &c.—In the mechanism of the foot three arches are distinguishable, two of them longitudinal and one transverse; all of them capable of being flattened somewhat by pressure from above, and combining to secure elasticity of the parts at rest or in motion. The inner arch is formed by the os calcis, astragalus, scaphoid, and

three cuneiform bones, together with the three inner toes; the head of the astragalus being the key stone, and being supported in its position, not by immoveable piers, as would be the case in an arch of mason-work, but by them in connection with the inferior calcaneo-scaphoid ligament. The outer arch is formed by the os calcis, cuboid bone, and two outer toes, and is supported by the strong inferior calcaneo-cuboid ligaments. Thus the calcaneo-scaphoid and calcaneo-cuboid ligaments are stretched by the whole weight of the body bearing down upon the arch, and prevent the too great flattening of the instep; an action in which they are assisted, however, by the plantar aponeurosis. The transverse arching of the foot is most marked along the line of tarso-metatarsal articulations, and is maintained by the wedge-shape of the bones and by inferior ligaments. The weight of the body, falling upon the balls of the toes when the heel is raised, tends to spread out the metatarsal bones at their distal extremities, and to flatten the transverse arch, which recovers its position when the pressure is removed. Between the astragalus and the calcaneum only one kind of motion is possible, the centre of which is the interosseous astragalo-calcaneal ligament, and is of such a nature, that when the posterior part of the os calcis slides inwards and upwards beneath the astragalus, its cuboid extremity moves downwards and outwards. A certain amount of gliding movement is also allowed between the tarsal and metatarsal bones, and that most considerably between the cuboid bone and outer toes. Thus it happens that if the foot is flexed against the leg, and then is gradually extended by force applied to the toes, as by the action of the flexores digitorum muscles, the first part of the movement is accomplished at the ankle, and consists of extension, with only a slight inward turning of the toes; further extension is accomplished by movement between the calcaneum and astragalus, and is accompanied by depression of the outer edge of the foot; and after that a little more extension, accompanied by more considerable depression of the outer edge of the foot, is effected at the tarso-metatarsal articulations. The direction of the movement of extension of the toes at the metatarso-phalangeal articulations is upwards and outwards, so that although the great toe is in a line with the inner edge of the foot when resting on the ground, it is no longer so when over-extended, as, for instance, when supported by a shoe.

Section III.—MYOLOGY.

Under the title Myology will be brought the systematic description of the form, position, and relations of the muscles of the body with their tendons, and in the same section it will be convenient to include that of the fasciæ and aponeuroses.

As many of the muscles consist of tendinous as well as muscular parts, the description of the tendons and their sheaths necessarily forms a part of that of the muscles; and farther, as it is impossible to separate the examination of the attachments of a muscle, or of groups of muscles, from the study of the motions produced by them, the statement of the action of the muscles will accompany their anatomical description.

In the description of the muscles, it is customary to state the attachments of their opposite ends under the names of *origin* and *insertion*; the first term being usually applied to the more fixed or proximal, and the second to the more movable or remote attachment: but it is to be observed, that it is sometimes difficult to lay down a rule for the correct use of these terms, and that in almost all instances it is of importance to consider the action of a muscle as it may affect the motions of the parts attached to both of its extremities.

As the muscles belong to the double symmetrical parts, it will be understood that it is sufficient, as in the bones and joints, to describe those occupying one side of the body.

The description of the involuntary and unstriped muscles connected with internal organs is excluded from the present section, as is also that of some small striped muscles situated in certain complicated organs, such as the larynx and ear, as it is more expedient that those muscles should be treated of under the several organs to which they belong. In the arrangement to be adopted in the anatomical description of the external and voluntary muscles, it is almost impossible to follow a strictly systematic order founded exclusively, either upon their position in the several regions of the body, or upon their actions: in the following section, therefore, an arrangement is adopted which is based in part on both of these considerations, and which seems to be the most simple and advantageous to the student.

Fasciæ.—The term Fascia includes all the membranous dispositions of reticulated or felted fibrous tissue. These structures have usually been distinguished as the *superficial* and the *deep;* the former consisting of looser and finer substances, and passing by their slenderer kinds into the finer varieties of connective tissue; while the latter, denser in character, frequently exhibit more or less regular arrangements of strong white fibres, giving them a shining appearance, and are often termed aponeuroses.

The connective tissue of the body being that in which all others are embedded, may be considered as forming a continuous meshwork of fasciæ of various degrees of firmness arranged so as to enclose shut spaces, within which the other parts are contained. Thus each fasciculus of muscle is surrounded by connective tissue; the larger fasciculi are separated by stronger partitions, and the whole muscle is invested with a layer of such distinctness, that it may appropriately be styled a fascia. So also the sheaths of vessels are formed of this substance; and in certain parts stronger septa, having attachment to bone, and continuous with the periosteum, which likewise belongs to the series of white fibrous membranes, form partitions between dissimilar structures.

Superficial Fascia.—Under this name, or as *subcutaneous fascia*, is described the layer of loose tissue of varying density, which is placed immediately below the skin, all over the body. It is the web which contains the subcutaneous fat, the *panniculus adiposus*, and in some regions superficial muscles, as the *panniculus carnosus*. From the subcutaneous tissue of the eyelids, however, as well as from that of the penis and scrotum, adipose matter is entirely absent. It is to be noticed also that between the muscles and the subcutaneous fat there is always a certain amount of fascia devoid of adipose matter, and that it is in this stratum that the trunks of the subcutaneous vessels and nerves are found. But when the fat becomes absorbed, the stroma in which it was deposited is still left, and its meshes approach one another, so that in lean subjects a more fibrous condition of the subcutaneous fascia is often found than in others.

Deep Fasciæ and Aponeuroses.—Under the name of deep fascia is comprehended that stronger layer of fibrous or connective tissue which, lying more close to the muscles, gives them a general investment or dips between them, and forms a nearly continuous covering of the body beneath the superficial fascia. It is chiefly to the stronger parts of this fascia that the name of aponeuroses has been given. Those covering the muscles have been named *aponeuroses of investment* (Bichat), to distinguish them from proper tendinous expansions, or *aponeuroses of insertion*, of muscles. This distinction, however, is far from being universally applicable: aponeuroses of insertion are often continued into aponeuroses of investment, as in the instance of the gluteus maximus, or into mere fascia, as at the lateral parts

of the occipito-frontal aponeuroses, or the cranial origin of the trapezius muscle. The principal aponeuroses of investment are those which incase the muscles of the limbs, binding them down in a common sheath, and connected in various places by septa with the bones. They are characteristic of the limbs, there being no structure entirely corresponding to them in the rest of the body.

MUSCLES OF THE HEAD AND NECK.

SUPERFICIAL MUSCLES.

EPICRANIAL MUSCLES.—Under the title of *occipito-frontalis* muscle are comprehended a pair of occipital and a pair of frontal muscles, together with a thin aponeurosis extending over the cranium, and uniting the anterior and posterior muscles together.

a. The *occipitalis* muscle, thin and subcutaneous, is attached inferiorly by short tendinous fibres to the external two-thirds, sometimes much less, of the superior curved line of the occipital bone, and to the mastoid portion of the temporal bone, immediately above the attachment of the sterno-mastoid muscle. Its fleshy fibres, from one to two inches in length, are directed upwards, and terminate in distinct tendinous fibres, continuous with the epicranial aponeurosis. Between the muscles of opposite sides is an interval of variable size occupied by a part of that aponeurosis.

b. The *frontalis* muscle, longer and broader and of a paler colour than the occipitalis, arises superiorly in a convex line from the epicranial aponeurosis, while inferiorly its innermost fibres are continuous with the pyramidalis nasi muscle, and the others are blended with the corrugator supercilii and with the orbicularis palpebrarum, as far outwards as the external orbital process of the frontal bone. The fibres are nearly vertical, running slightly inwards; the margins of the right and left muscle are united for a short distance above the root of the nose, but are separated by an angular interval superiorly.

c. The *epicranial* or *occipito-frontal aponeurosis* extends over the upper surface of the cranium uniformly from side to side, without division. Posteriorly it is attached to the occipitales muscles, and to the protuberance and superior curved lines of the occipital bone, and anteriorly it terminates in the frontales muscles, while laterally it presents no distinct margin, but below the temporal ridge becomes thinner and less aponeurotic, and gives attachment to the superior and anterior auricular muscles. Its fibres are chiefly longitudinal, and are most distinctly tendinous where they give attachment to the occipitales muscles. Its outer surface is firmly bound to the skin by an abundant network of fibrous tissue, constituting the so-called superficial fascia, by the meshes of which the subcutaneous fat is divided into granules; while its deep surface glides upon the subjacent pericranium, to which it is loosely adherent through the medium of a delicate connective tissue devoid of fat.

ACTIONS.—By the contraction of the whole occipito-frontalis muscle, the scalp is drawn backwards, and the eyebrows elevated; by the contraction of the frontales muscles alone, the eyebrows are elevated, the scalp pulled forwards, and the skin of the forehead thrown into transverse wrinkles; by the contraction of the occipitales muscles alone, the scalp is drawn backwards; and by the alternate action of the occipitales and frontales muscles, the scalp is moved backwards and forwards. In

many persons, however, there is only a partial control over the action of these muscles, limited to the elevation of the eyebrows and horizontal wrinkling of the forehead.

Auricular Muscles.—Besides minute bundles of muscular fibres which pass from one part of the pinna of the auricle to another, and which will be

Fig. 153.

Fig. 153.—Superficial View of the Muscles on the left side of the Head and Neck (slightly altered from Bourgery). ½

a, cranial aponeurosis; *b*, superior curved line of the occipital bone; *c*, ramus of the lower jaw; *d*, lower edge of the hyoid bone; *e*, head of the clavicle. 1, anterior or frontal, and 1′, posterior or occipital part of the occipito-frontalis muscle; *a*, the aponeurotic covering of the cranium extending between the two portions of the muscle; 2, superior auricular; 2′, anterior auricular; 3, posterior auricular in two fasciculi; 4, is placed in front of the temple close to the outer part of the orbicularis palpebrarum; 5, pyramidalis nasi; 6, triangularis nasi or compressor narium; 7, levator labii superioris alæque nasi; 8, orbicularis oris;

8′, its attachment to the columella nasi, or depressor nasi; 9, levator labii superioris, and close by it zygomaticus minor; farther back passing from the + obliquely down towards 8, zygomaticus major; and between the zygomatici, in shadow, is seen a portion of the levator anguli oris; 10, quadratus menti or depressor labii inferioris; 11, triangularis oris or depressor anguli oris; 12, points to the situation of levator menti; 13, is placed on the masseter, it is immediately above the risorius or upper horizontal fibres of the platysma myoides, and a line points from it to the buccinator; 14, platysma myoides; 15, placed on the upper part of the sterno-mastoid, points by a line to the posterior belly of the digastric muscle; 15′, the sternal tendon of the sterno-mastoid, a part of its clavicular portion is seen near *e*: 16, trapezius; 17, splenius capitis; +, splenius colli; 18, levator scapulæ; 19, sterno-hyoid; 20, omo-hyoid; 21, pectoralis major, its pectoral part; 21′, its clavicular part; 22, deltoid.

most conveniently described along with that structure, there are attached to the external ear three larger, but still very slightly developed, muscles, which serve to move it as a whole.

The *auricularis superior* or *attollens auriculam*, the largest of the three, arises in the temporal region of the head from the epicranial aponeurosis. Its fibres are extremely delicate, and radiated in arrangement, and are inserted by a compressed tendon into the cartilage of the ear at the upper and anterior part of the helix and upper part of the concha.

The *auricularis anterior* or *attrahens auriculam*, scarcely separated from the preceding muscle, is pale and indistinct, and is attached to the thin lateral prolongation of the epicranial aponeurosis, from which it passes backwards to be inserted into the fore part of the helix.

The *auricularis posterior* or *retrahens auriculam* muscle, consists of two or three thin fasciculi, which arise from the mastoid process by short aponeurotic fibres, and are inserted into the back part of the concha. The fibres are much deeper in colour and more distinctly marked than in either of the other auricular muscles.

Actions.—The three auriculares muscles respectively draw the pinna of the ear upwards, backwards, and forwards. In the majority of persons their action is not directly under voluntary control.

Muscles of the Eyelids.—These are four in number—namely, the orbicularis palpebrarum and tensor tarsi, the corrugator supercilii, and the levator palpebræ superioris.

The *orbicularis palpebrarum* is a thin elliptical muscle closely adherent to the skin, surrounding the fissure between the eyelids and covering their surface, and spreading for some distance outwards on the temple, upwards on the forehead, and downwards on the cheek. The fibres forming concentric curves are attached by their extremities at the inner angle of the orbit: 1st, to the edges and anterior surface of the tendon afterwards described; 2nd, to the surface of the nasal process of the superior-maxilla, near the anterior margin of the lachrymal groove; and 3rd, to the internal angular process of the frontal bone.

The fibres situated in the eyelids are thin, pale and little curved, and conceal the tarsal cartilages: they are sometimes distinguished by the name "ciliaris." The peripheral fibres, "orbicularis latus," more largely developed, rest on the cheek and margin of the orbit. Superiorly this muscle conceals the corrugator supercilii, with which and the occipito-frontalis it is intimately connected; inferiorly it covers the origin of the elevators of the upper lip, part of the common elevator of the lip and nose, and the lachrymal sac; and externally it lies upon a part of the temporal fascia.

The *tendon* of the orbicularis muscle (tendo palpebrarum).—At the inner commissure of the eyelids is a small tendon, which is often obscured by the

fibres of the muscle, but is rendered apparent by drawing the lids outwards. This tendon is about two lines in length, and less than one in breadth, and is attached to the anterior margin of the lachrymal groove ; thence it runs

Fig. 154.

Fig. 154.—SUPERFICIAL AND DEEP VIEW OF THE MUSCLES OF THE HEAD AND NECK, FROM BEFORE (altered from Bourgery). ½

On the left side, the platysma alone has been removed ; on the right side, portions of the zygomatic arch and clavicle, the superficial muscles of the cranium and face, the masseter, trapezius, sterno-mastoid and pectoralis major muscles have been removed ; *a*, right alar cartilage of the nose ; *b*, upon the lobe of the right ear, points to the coronoid process of the lower jaw ; *c*, the body of the hyoid bone ; *d*, symphysis of the lower jaw ; *e*, upon the subclavian groove of the first rib, lying in which is the cut end of the subclavian artery ; *f*, the glenoid cavity of the scapula ; *g*, the right zygomatic arch separated from the malar bone ; *h*, upon the temporal ridge of the frontal bone ; *i*, above the supra-orbital ridge ; 1, frontalis muscle ; 2, superior auricular ; 2′, insertion of the anterior

auricular; 3, corrugator supercilii; 4, malar portion of the orbicularis palpebrarum; 4', palpebral portion; below *i*, the expanded insertion of levator palpebræ superioris in the eyelid; 5, pyramidalis nasi; 6, insertion of the triangulares nasi on the dorsum of the nose; 7, levator labii superioris alæque nasi; 8, orbicularis oris of the left side; 8', outer part of the same on the right side, the inner part being removed; 9, levator labii superioris; +, zygomaticus minor; 10, zygomaticus major; 11, depressor anguli oris; 12, depressor labii inferioris; *d*, points to the cut ends of the levatores menti; 13, placed on the left masseter, points to the buccinator; 13', buccinator, of the right side, a portion of the parotid duct passing through the muscle; 14, levator anguli oris, seen also on the left side behind the zygomaticus minor. The remaining references which apply to the muscles of the neck will be found described at page 194.

horizontally outwards to the inner commissure of the eyelids, where it divides into two thin fibrous lamellæ, which diverge as they pass outwards in the substance of the eyelids, and terminate in the tarsal cartilages. One surface of the tendon is subcutaneous; the other crosses the lachrymal sac a little above the centre, and from it a thin but firm fascia is given off, which spreads over the lachrymal sac, and adheres to the margins of the groove which lodges it.

The *tensor tarsi*—Horner, (musculus sacci lachrymalis,)—consists of very thin fibres resting on the fascia just mentioned. It is only a deep portion of the insertion of the marginal fibres of the ciliary part of the orbicularis muscle: two slips, one from each eyelid, passing behind the lachrymal canals, unite on the surface of the lachrymal sac before reaching their attachment on the posterior part of the lachrymal bone.

The *corrugator supercilii* is a small muscle narrower below than above, placed at the inner side of the eyebrow. It arises from the inner extremity of the superciliary ridge of the frontal bone; thence its fibres proceed outwards and a little upwards, and end, at the middle of the orbital arch, by becoming blended with those of the orbicularis and occipito-frontalis muscles, by which it is concealed.

This muscle crosses the supra-trochlear branch of the ophthalmic nerve and the accompanying artery as they emerge from the orbit.

The *levator palpebræ superioris* is a muscle occupying the upper part of the orbit, but the insertion of which is seen in the dissection of the upper eyelid, in which it forms a broad fibrous expansion which curves downwards towards its margin, and is inserted under cover of the orbicularis muscle into the forepart of the tarsal cartilage. It will be described along with the muscles of the orbit.

Actions.—The orbicularis palpebrarum closes the eyelids. In the ordinary closure of the eye, it is chiefly the upper lid which moves, being depressed by the superior half of the ciliary part of the muscle; but in forcible closure both eyelids move, and not only come together, but are drawn towards the nose at the same time that the eyebrows are drawn downwards and inwards, the whole fibres of the orbicularis being thus contracted and approached towards the tendo palpebrarum. In those circumstances the fibres which form the tensor tarsi, being contracted like the others, compress the lachrymal sac, and prevent the introduction into it of the lachrymal secretion from the conjunctiva. The corrugator muscles draw the skin of the forehead downwards and inwards, raising longitudinal furrows, as in frowning. The upper eyelid is supported by the levator palpebræ, and droops when that muscle is paralysed. On the other hand, paralysis of the orbicularis is attended by an inability to close the eyelids.

Muscles of the Nose.—Under this head may be conveniently grouped not only the compressor naris and smaller muscles which act upon the nose alone, but also the pyramidalis nasi which acts on the forehead, and the levator labii superioris alæque nasi whose action is common to the nose and lip.

The *pyramidalis nasi*, continuous with the innermost fibres of the frontalis muscle, extends downwards from the root of the nose, over the upper part of it, and terminates by a tendinous expansion in connection with the compressor naris muscle. The muscles of opposite sides, united superiorly, diverge slightly as they descend.

The *compressor naris*, a thin triangular muscle, arises narrow and fleshy from the canine fossa in the superior maxillary bone, and proceeding inwards, gradually expands into a thin aponeurosis, which is partly blended with that of the corresponding muscle of the opposite side, and with the pyramidalis nasi, and is partly attached to the cartilage of the nose. It is concealed at its origin by the proper elevator of the lip, and is crossed by the common elevator.

Fig. 155.

Fig. 155.—Muscles of the side of the Nose and Upper Lip. ⅔

1, pyramidalis nasi; 2, levator labii superioris alæque nasi; 3, compressor naris or triangularis; 4, levator proprius alæ nasi anterior; 5, levator proprius alæ nasi posterior or dilatator; 6, depressor alæ nasi; 7, orbicularis oris; 7*, naso-labialis.

The *levator labii superioris alæque nasi*, the common elevator of the lip and nose, lies along the side of the nose, extending from the inner margin of the orbit to the upper lip. It arises by a pointed process from the upper extremity of the nasal process of the superior maxillary bone, and, as it descends, separates into two fasciculi; one of these, much smaller than the other, becomes attached to the wing of the nose, whilst the other is prolonged to the upper lip, where it is blended with the orbicularis and the special elevator muscle. It is subcutaneous, except at its origin, where the orbicularis palpebrarum overlaps it a little.

Anomalous Fibres.—Beneath the common elevator of the lip and ala of the nose, and connected by the lower end with the origin of the compressor naris, will be found a longitudinal muscular slip, more than an inch in length, attached exclusively to the superior maxillary bone. It was named "rhomboideus" by Santorini, and (in consequence of being attached only to one bone, and producing therefore no motion) "anomalus" by Albinus.

The *depressor alæ nasi* is a small flat muscle which arises from the superior incisor fossa, and is inserted into the septum and posterior part of the ala of the nose. The external fibres curve forwards and downwards to the ala.

Besides the muscles above described there are other irregular and often indistinct fibres which cover the small alar cartilages of the nose. Of these the following may be distinguished.

The *levator proprius alæ nasi posterior*, or *dilatator naris posterior*, is attached to the margin of the ascending process of the superior maxillary bone and the smaller (sesamoid) cartilages of the ala nasi on the one hand, and to the skin on the other. Another set of fibres, the *levator proprius alæ nasi anterior*, or *dilatator naris anterior*, is interposed between the cartilage of the aperture of the nose and the skin, to both of which it is attached.

Actions.—The pyramidalis muscle, being continuous with the occipito-frontalis, is the means of giving that muscle a more fixed attachment to the dorsum of the nose,

and must aid it in drawing down the integument of the forehead; but it probably acts also as an opponent to the compressor naris muscle. The compressor naris, acting along with its fellow of the other side, depresses the cartilaginous part of the nose, and to some extent also compresses the alæ together. The actions of the other muscles are sufficiently indicated by their names; the dilatation of the alæ is perceptible in natural inspiration, and is well marked in dyspnœa.

MUSCLES OF THE LIPS AND MOUTH.—Around the orifice of the mouth are situated an orbicular muscle with concentric fibres, and numerous other muscles, whose fibres converge towards the aperture, viz., superiorly the common elevator of the lip and nose already described, the proper elevator of the upper lip, the elevator of the angle of the mouth and the zygomatic muscles, laterally the risorius and buccinator muscles, and, inferiorly, the depressor of the angle of the mouth and that of the lower lip; and lastly, acting indirectly on the lower lip, the levator menti.

The *orbicularis oris*, or *sphincter oris*, consists of a labial or inner, and a facial or peripheral part. The *labial* or *marginal portion* reaches outwards from the oral aperture as far as the red part of the lip, and forms a slightly convex fasciculus of pale fine fibres closely applied to each other. Its fibres are free from bony attachment, and are traceable from one lip to another round the corner of the mouth. The *facial portion*, thinner and wider than the other, blends by its outer border with the several muscles that converge to the mouth from the contiguous parts of the face, and is more particularly stretched outwards by its attachment to the buccinator muscle, the fibres of which seem almost to be continuous with the deeper part of the orbicularis. Besides those fibres it has others that are attached to the subjacent cartilage and bone; viz., in the upper lip two bundles for each half; and in the lower lip one for each. In the upper lip one of the fleshy slips (accessorius orbicularis superioris) is thin and weak, and is attached opposite the incisor teeth, close to the alveolar edge of the upper jaw-bone; and the other, thicker and pointed, is fixed to the septum of the nose. In the lower lip the reinforcing fasciculus (accessorius orbicularis inferioris) arises from the surface of the lower jaw, near the root of the canine tooth, and external to the levator labii inferioris. From these points of attachment the fibres are directed outwards towards the angle of the mouth and blend with the rest.

To the inner part of the orbicularis oris muscle the skin of the lips is closely connected, whilst over the outer part fatty tissue is interposed between them. The deep surface is in contact with the mucous membrane and the labial glands, as well as with the coronary arterial arch in each lip.

The *levator labii superioris* arises immediately above the infra-orbital foramen, close to the lower border of the orbit, from the superior maxillary and malar bones, and passes downwards and a little inwards to be blended with the orbicularis and other muscular fibres in the upper lip.

At its origin this muscle is overlapped by the orbicularis palpebrarum, but its lower part is subcutaneous; it partly conceals the levator anguli oris, and the compressor naris, and beneath it the infra-orbital vessels and nerve emerge from the canal of that name.

The *levator anguli oris*, or *musculus caninus*, arises in the canine fossa immediately below the infra-orbital foramen, inclines downwards and slightly outwards, and is inserted into the angle of the mouth.

At its origin this muscle is concealed by the elevator of the upper lip; its anterior

surface supports the infra-orbital nerve and artery, which separate it from the preceding muscle; the posterior surface lies on the superior maxilla and the orbicularis and buccinator muscles, with which and the depressor anguli oris the fibres are blended.

The *zygomatici* are two narrow and subcutaneous fasciculi of muscular fibres, extending obliquely from the most prominent part of the cheek to the angle of the mouth, one being thicker and longer than the other.

a. The *zygomaticus minor*, a very small muscle, arises from the anterior and inferior part of the malar bone, and inclines downwards and forwards to terminate by joining the outer margin of the levator labii superioris; sometimes near the origin of that muscle. It lies internal to the zygomaticus major, but distinct from it in the whole length, and is sometimes joined by some fibres of the orbicularis palpebrarum: in some instances it is replaced by a fleshy slip from that muscle; in others it is altogether wanting.

b. The *zygomaticus major*, placed externally to the smaller muscle of the same name, arises from the malar bone near the zygomatic suture, from which it descends to the angle of the mouth, where it is continued into the orbicularis and depressor anguli oris.

The *risorius* or smiling muscle (Santorini), consisting of some very thin fasciculi, commences in the fascia over the masseter, or on the parotid gland, and extending transversely inwards in the fat of the cheek, joins the orbicularis and depressor anguli oris at the angle of the mouth. It is united with the fibres of the platysma close to their termination, and is by many regarded as a part of that muscle.

The *buccinator* muscle consists of a flat and thin but strong set of fibres in contact with the mucous membrane, and forming a considerable part of the wall of the mouth. It is attached by its upper and lower margins to the outer surface of the alveolar parts of the maxillary bones, outside the molar teeth, and between these bones it is fixed behind to a narrow band of tendinous fibres, the *pterygo-maxillary ligament*, a structure which extends from the internal pterygoid plate to the posterior extremity of the mylo-hyoid ridge of the lower jaw close to the last molar tooth, and separates the buccinator muscle from the superior constrictor of the pharynx. From these points the fibres of the muscle are directed forwards, approaching each other, so that the muscle is narrowed and proportionally thickened near the angle of the mouth, where it becomes incorporated with the orbicularis. The fibres near the middle of the muscle cross each other, those from above entering into the lower lip, and those from below into the upper one; but the higher and lower fibres are directed into the corresponding lip without decussation.

The buccinator is covered and supported by a thin fascia, which is closely adherent to the muscular fibres; and is overlapped by the triangularis oris, the terminal fibres of the platysma myoides, and by the facial artery and vein; it is also covered by the masseter and zygomatici, from which it is separated by a quantity of soft adipose tissue of a peculiar character. Opposite the second molar tooth of the upper jaw, its fibres give passage to the duct of the parotid gland.

The *depressor anguli oris*, or *triangularis oris*, is broad at its origin from a line on the external surface of the lower jaw near its base; passing upwards it is collected into a narrower bundle which is inserted into the orbicularis at the angle of the mouth.

This muscle is covered by the skin, and, at its insertion, by the zygomaticus major, under which its fibres pass; it conceals part of the buccinator and of the depressor of the lower lip.

Fig. 156.

Fig. 156.—Deep view of the Muscles of the left side of the Head and Neck (modified from Bourgery). ⅓

a, vertex of the head; *b*, superior curved line of the occipital bone; *c*, ramus of the lower jaw; *c'*, its coronoid process; *d*, body of the hyoid bone; *e*, sternal end of the clavicle; *e'*, acromial end; *f*, malar bone divided to show the insertion of the temporal muscle; *f'*, zygoma divided, and external lateral ligament of the jaw; *g*, thyroid cartilage; *h*, placed on the lobe of the auricle, points to the styloid process; 1, temporal muscle; 2, corrugator supercilii; 3, pyramidalis nasi; 4, lateral cartilage of the nose covered by the triangularis nasi; 5, levator labii superioris proprius; 6, levator anguli oris; 7, outer part of the orbicularis oris, the part below the nose has been removed to show more deeply 8, depressor alæ nasi; 9, placed on the ramus of the jaw, points to the buccinator muscle, through which the parotid duct is seen passing; 10, quadratus menti; 11, levator menti; 12, 12, anterior and posterior bellies of the digastric; 13, placed on the angle of the jaw, points to the stylo-hyoid muscle; 14, points to the mylo-hyoid; 15, to the hyo-glossus, between which and 13, is seen a part of the stylo-glossus; 16, sterno-hyoid; 17, on the clavicle, indicates the lower, and 17', the upper belly of the omo-hyoid; 18, a small part of the sterno-thyroid; 19, thyro-hyoid; 20, 21, on the sterno-mastoid muscle, point, the first to the middle, the second to the lower constrictor of the pharynx; 22, trapezius; 23, upper part of the complexus; 24, splenius capitis; 25, splenius colli; 26, levator scapulæ; 27, middle scalenus; +, posterior scalenus; 28, anterior scalenus.

The *depressor labii inferioris*, or *quadratus menti*, arises from the lower jaw by a line of attachment extending from near the symphysis to a little beyond the mental foramen ; thence it ascends with an inward inclination, unites with its fellow, and blending with the orbicularis oris is inserted into the lower lip. Its fibres are intermixed with much adipose matter.

It covers the nerve and artery issuing from the mental foramen.

The *levator labii inferioris* or *levator menti* arises by a narrow head from the incisor pit of the lower jaw, and expanding in a nearly vertical plane, is directed forwards, downwards, and slightly inwards to the integument of the chin between the depressors of the lower lip.

Actions.—The orbicularis oris acting alone draws the lips together in both the vertical and transverse directions. Acting in conjunction with the buccinators it closes the lips, while at the same time they are elongated transversely. Its facial portion acting alone projects the lips. The labial portion, when acting in concert with the converging muscles, tightens the lips, one or both, against the teeth. The convergent muscles each draw their oral points of insertion in a direction corresponding to that of their muscular fibres. The common elevator of the lip and nose and the upper part of the orbicularis oris act on both the upper lip and the ala of the nose together—the one elevating, the other depressing them. When the cheeks are distended with air in the mouth, it is by the action of the buccinator that the rush of the air through the narrowed oral aperture is regulated, as in whistling, or performance on a wind instrument; hence the name "trumpeter's muscle" sometimes given to the buccinator. The levator menti not only draws upwards the integument of the chin, but it also protrudes the lower lip, as in pouting. The muscles attached to the angles of the mouth are, along with others of the face, intimately connected with the expression of the passions: those which pass downwards not only raise the upper lip, but also push upwards the cheek, and thus elevate the margin of the lower eyelid, as in laughter; and those which descend from the angle of the mouth depress that part, as in weeping. (On the action of the facial muscles may be consulted, more especially, Sir Charles Bell, "Anatomy and Philosophy of Expression.")

The Platysma myoides is a pale coloured thin sheet of muscular fibres, superficial to the deep cervical fascia, and extending over the front and sides of the neck and lower portions of the side part of the face. Its fibres, which are pale and thin in their whole extent, rise by thin bands from the clavicle and acromion, and from the fascia covering the upper part of the deltoid, pectoral, and trapezius muscles; thence they proceed upwards and inwards over the clavicle and the side of the neck, gradually narrowing and approaching the muscle of the opposite side. At the lower jaw the greater number of the fibres are inserted into the side of that bone from the symphysis to the attachment of the masseter; the inner fibres mingle with those of the opposite platysma in front of the symphysis, and even cross from the one side to the other below the chin, for about an inch, those of the right side overlapping those of the left; and the posterior fibres are prolonged upon the side of the face as far as the angle of the mouth, where they become blended with the muscles in that situation, or in some instances they reach the fascia over the parotid gland, and the cheek-bone. The uppermost fibres pass into those receiving the name of risorius.

Action.—The platysma, being much less developed in man than in animals, has a comparatively limited action in the human subject; it assists in drawing the angle of the jaw downwards and outwards, and protects parts more deeply situated in the

neck. It is the only representative of a subcutaneous group of muscles largely developed in most mammals, by which very varied movements of the skin and some superficial parts may be given, as, for example, when the horse communicates a rapid motion to the skin to free itself from insects, or the dog shakes off the water after swimming, or the hedgehog elevates its spines; and which is known collectively as the *panniculus carnosus*.

MUSCLES OF THE ORBIT.

In this group will be described seven muscles, namely, the elevator of the upper eyelid already alluded to, and six muscles of the eyeball, viz., the four straight and the two oblique muscles. Of these muscles the inferior oblique alone is confined to the fore part of the orbit, all the rest take their origin at its back part, and pass longitudinally forwards to their insertions in front.

The *levator palpebræ superioris* is a slender muscle, which arises, pointed and tendinous, above and in front of the margin of the optic foramen, and passing forwards over the eyeball, ends in a fibrous expansion inserted into the anterior surface of the tarsal cartilage of the upper eyelid.

Between this muscle and the roof of the orbit are situated the fourth and frontal nerves, and beneath it are the superior rectus muscle and the globe of the eye. In the lid, it is placed behind the palpebral ligament, close to the membrana conjunctiva.

The four straight muscles of the eye surround at their origin the optic nerve, and passing forwards from that point, are inserted into the front of the globe of the eye at four opposite equi-distant parts, by delicate expanded tendons which become blended into one at their termination.

The *superior rectus* arises close in front of the foramen opticum, and beneath the levator palpebræ; the *inferior rectus*, *internal rectus*, and *external rectus* are united in a common tendinous attachment around the circumference of the optic foramen, except above. But the external rectus differs from the others in having two heads of origin; the upper head unites with that of the superior rectus, the second head arises from a bony point on the lower margin of the sphenoidal fissure close to its wider inner end; and other fibres are implanted into a fibrous band between the heads of origin. The four recti thus attached posteriorly, pass forwards, one above, one below, and one on each side of the eyeball, becoming flattened as they lie in contact with it, and are inserted by short membranous tendons into the fore part of the sclerotic coat, at an average distance of four lines from the margin of the cornea.

In length and breadth there are some differences among these muscles. The external rectus exceeds the internal one in length. On the other hand, the internal rectus has some advantage in width, being broader than any; and the superior appears rather the narrowest of all. Between the heads of the external rectus is a narrow interval, which gives transmission to the third and sixth nerves and the nasal branch of the fifth nerve, with the ophthalmic vein.

The *superior oblique* or *trochlearis* is a narrow elongated muscle, placed at the upper and inner part of the orbit, internally to the levator palpebræ. It arises about a line in front of the inner part of the optic foramen; thence it proceeds towards the internal angle of the orbit, and terminates in a round tendon, which passes through a fibro-cartilaginous ring or pulley

(trochlea) attached to the fovea trochlearis of the frontal bone; it is there reflected outwards and backwards, and passes between the eye and the superior rectus, to be inserted into the sclerotic coat midway between the superior and external recti muscles, nearly equi-distant from the cornea and the entrance of the optic nerve. A synovial sheath lines the contiguous surfaces of the tendon and pulley.

This muscle is covered by the roof of the orbit, the fourth nerve entering its upper surface; and beneath it lie the nasal nerve and the internal rectus muscle.

Fig. 157.

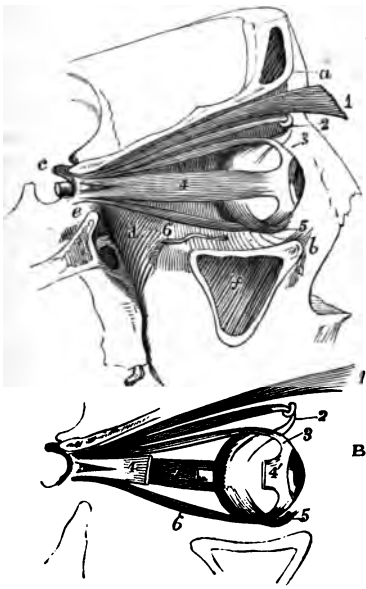


Fig. 157.—A, VIEW OF THE MUSCLES OF THE RIGHT ORBIT, FROM THE OUTSIDE, THE OUTER WALL HAVING BEEN REMOVED. $\frac{1}{2}$

B, EXPLANATORY SKETCH OF THE SAME MUSCLES.

a, supraorbital ridge; *b*, lower margin of the orbit formed by the superior maxillary bone; *c*, anterior clinoid process; *d*, posterior part of the floor of the orbit above the spheno-maxillary fossa; *e*, side of the body of the sphenoid bone below the optic foramen and sphenoidal fissure; *f*, sinus maxillaris; 1, anterior part of levator palpebræ superioris, where it is inserted into the eyelid; 2, pulley and tendon of the superior oblique muscle; 3, tendon of the superior rectus muscle at its insertion upon the eyeball; 4, in A, outer surface of the external rectus; 4′, in B, the anterior or inserted tendon of the same muscle, a part of which has been removed; the double origin of the muscle is shown at the apex of the orbit; 5, the inferior oblique muscle crossing the eyeball below the inferior rectus; 6, the inferior rectus; 7, in B, the inside of the internal rectus, seen in consequence of the removal of a part of the external rectus, and near it, the end of the optic nerve cut short close to the place of its entrance into the eyeball.

The *inferior oblique* is the only muscle of the eye which does not take origin at the apex of the orbit. It arises from a minute depression in the orbital plate of the superior maxillary bone, just within the anterior margin of the orbit, and close to the external border of the lachrymal groove. The muscle inclines outwards and backwards between the inferior rectus and the floor of the orbit, and ends in a tendinous expansion, which passes between the external rectus and the eyeball, to be inserted on the external and posterior aspect of the globe.

ACTIONS.—The recti muscles turn the eye upwards, downwards and from side to side, thus placing the axis of the eye in these or any intermediate directions. Evidence is against the supposition that the recti muscles are capable of altering the position of the eyeball in an antero-posterior direction, nor is it probable that they can in any perceptible degree change its form. (Jacob, "On Paralytic, Neuralgic, and other Nervous Diseases of the Eye," in "Dublin Med. Press," 1841; G. Johnson, the article "Orbit," in "Todd's Cyclopedia of Anatomy and Physiology.")

MUSCLES OF THE JAW.

The masseter, temporal, and two pterygoid muscles form a group of muscles of mastication, which may be properly considered together.

The *masseter* is a thick quadrate muscle, whose fibres are arranged so as to form two portions differing in size and direction. The *superficial* part arises from the anterior two-thirds of the lower border of the zygomatic arch, chiefly by thick tendons projecting down between the muscular fasciculi, to which they afford an extensive surface of origin : its fibres proceed downwards and a little backwards to be inserted into the lower half of the ramus of the jaw, extending as far as the angle. The fibres of the *deep* part of the muscle, much shorter than those of the superficial part, and directed downwards and forwards, arise from the posterior third of the lower border and from all the deep surface of the arch, and becoming united with the superficial part, are inserted into the upper half of the ramus of the jaw, including the coronoid process: only the upper and back part of this portion of the muscle is left uncovered by the superficial portion.

The external surface of the masseter muscle is covered for the most part only by the skin and fascia; it is, however, overlapped behind by the parotid gland, and crossed by its duct; the branches of the facial nerve and the transverse facial artery also rest upon it. Its inner surface is towards the buccinator, from which it is separated by some soft adipose tissue; it is in intimate contact with the ramus of the jaw, and covers a nerve and vessels which enter it over the sigmoid notch of that bone.

The *temporal* muscle (*crotaphite*—Winslow) is fan-shaped, occupies the temporal fossa, and arises from the whole surface of that fossa, with the exception of the anterior or malar wall; it likewise takes origin from the deep surface of the temporal fascia, which passes down over it to the zygoma, and some of its posterior fibres arising from this fascia are blended with the deep fibres of the masseter muscle. The direction of the anterior fibres is nearly vertical, that of the middle fibres oblique, and that of the posterior fibres at first horizontal. The fasciculi from this extensive origin converge as they descend, and all terminate in a tendon, which, emerging from the interior of the muscle, is implanted into all the inner surface as well as the anterior border of the coronoid process of the lower jaw-bone, as far down as the union of the body and ramus of the jaw, where they are blended with the origin of the buccinator muscle.

The upper part of the muscle is in contact with the temporal fascia; the lower and anterior part is imbedded in fat continuous with that which lies between the masseter and buccinator muscles; the insertion of the tendon is mainly concealed by the lower jaw. Between the muscle and the temporal fossa are the deep temporal arteries and the temporal nerves, which penetrate its substance. In contact with the deep surface of the muscle near its insertion the buccal nerve descends, and at the posterior border of the insertion the masseteric nerve and artery emerge.

The *internal pterygoid* muscle is related to the inner surface of the ramus of the jaw, somewhat in the same manner as the masseter is to the outer. It arises from the pterygoid fossa; its fibres, tendinous and fleshy, being attached mostly to the inner surface of the external pterygoid plate, and that portion of the tuberosity of the palate-bone which is situated between the pterygoid plates. Thence it is inclined downwards, with a direction

backwards and outwards, and is inserted into the angle and the inner surface of the ramus of the jaw as high as the dental foramen.

Between the external surface of the muscle and the ramus of the maxilla are the internal lateral ligament and the internal maxillary vessels, with the dental artery and nerve; and at its upper part the muscle is crossed by the external pterygoid muscle. Its inner surface, whilst in the pterygoid groove, is in contact with the tensor palati muscle; and lower down it corresponds with the superior constrictor of the pharynx.

Fig. 158.

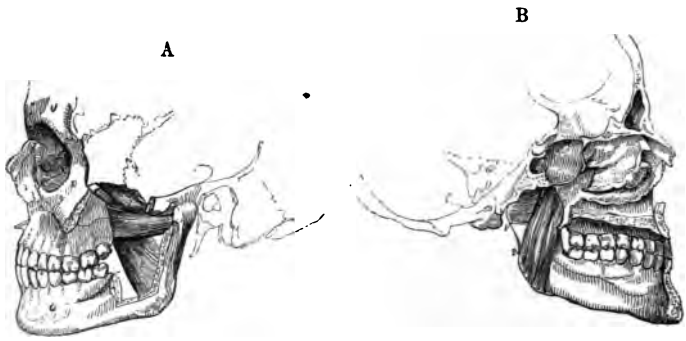


Fig. 158.—Views of the Pterygoid Muscles—A, from the outer side; B, from the inner side. ½

1, external pterygoid, placed on the upper head in A, on the lower head in B; 2, internal pterygoid—the outer surface in A, the inner surface in B.

Fig. 159.

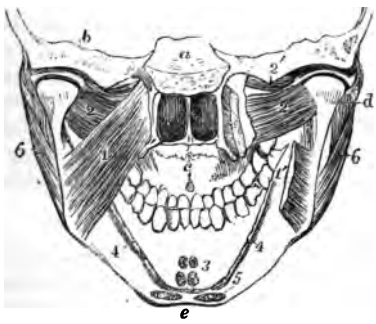


Fig. 159.—View of a Dissection of the lower part of the Skull and Face, from behind, designed to show the attachments of the Pterygoid and some other Muscles (modified from Bourgery). ½

a, placed above the transverse section of the basilar part of the occipital bone, below which are seen the posterior nares and palate; *b*, transverse section through the temporal bone; *c*, roof of the mouth; *d*, back of the head and neck of the lower jaw, above which are seen the synovial cavities of the joint divided by the interarticular fibro-cartilage; *e*, placed below the symphysis menti; 1, on the left side the internal pterygoid muscle entire; 1′, on the right side the lower part of the same muscle, of which the middle portion has been removed to show the external pterygoid; 2, the lower thick portion of the external pterygoid; 2′, on the right side, points to the upper smaller portion of the muscle, attached in part to the interarticular plate; 3, is placed at the side of small portions of the genio-hyoid and genio-hyoglossus muscles cut short at their attachment to the lower and upper genial tubercles; 4, the attachment of the mylo-hyoid muscle cut short; 5, indicates the attachment at the side of the symphysis of the anterior belly of the digastric muscle; 6, the masseter muscle descending to the angle of the jaw.

The *external pterygoid* muscle, occupying the zygomatic fossa, arises by two fleshy heads placed close together, the superior of which is attached to

that part of the external surface of the great wing of the sphenoid bone which looks downwards, and to the ridge which separates that surface from the temporal fossa; while the inferior, which is larger, is attached to the outer surface of the external pterygoid plate, and to the tuberosities of the palate and upper maxillary bones. The fibres from both heads pass backwards, and being mixed with tendon, converge to be inserted into the fore part of the neck of the condyle of the lower jaw, and into the inter-articular fibro-cartilage of the temporo-maxillary articulation.

The internal maxillary artery is placed on the outer surface of this muscle, passing thence between the heads of origin; while the buccal nerve issues from between those heads. The deep surface rests against the upper part of the internal pterygoid muscle, whose direction it crosses, also the internal lateral ligament of the lower jaw, the inferior maxillary nerve, and the middle meningeal artery. The upper border is in contact with the great wing of the sphenoid bone, and is crossed by the deep temporal nerve and arteries.

ACTIONS.—The masseter, temporal, and internal pterygoid muscles are elevators of the lower jaw, and generally act in concert, bringing the lower in contact with the upper teeth. The opposite movement of depressing the jaw, not being opposed by any resisting obstacle, requires less force, and is effected by muscles of much smaller size, the principal of which is the digastric muscle hereafter described. The external pterygoid muscle, having the great body of its fibres nearly horizontal, draws forwards the condyle of the jaw, and when the muscles of both sides act together, the lower jaw is protracted so as to make the inferior incisor teeth project beyond the upper incisors; but their more usual mode of action is alternately on the two sides, as in the grinding movement of the molar teeth, in which a variety of muscular actions are combined. The external pterygoid muscles also, though chiefly horizontal movers of the jaw, likewise contract in opening the mouth, the condyles of the jaw being drawn forward in that movement. The masseter and internal pterygoid muscles assist in protracting the jaw; the temporal alone is a retractor. The two pterygoid muscles of one side, in advancing one condyle of the jaw, necessarily throw the teeth towards the opposite side.

SUBMAXILLARY MUSCLES.

A. MUSCLES CONNECTING THE HYOID BONE WITH THE SKULL.

The *digastric* muscle, extending from the temporal bone to the lower jaw, consists of two elongated muscular bellies united by an intervening rounded tendon, which is connected with the hyoid bone. The posterior belly, which is longer than the anterior, arises from the digastric groove of the temporal bone, and tapers downwards, forwards, and inwards: the anterior is attached to a rough depression situated on the lower border of the jaw-bone, close to the symphysis; it is less tapering than the posterior belly, and is directed downwards and backwards. The intervening tendon is connected with the body and great cornu of the os hyoides by aponeurotic fibres at right angles to its own, and by the fleshy fibres of the stylo-hyoid muscle, through which the tendon passes.

The anterior belly, placed immediately beneath the deep cervical fascia, rests on the mylo-hyoid muscle; it is connected with its fellow of the opposite side by dense fascia, and occasionally is united by muscular fibres to it or to the mylo-hyoid muscle. The posterior belly is covered by the mastoid process and the muscles arising from that bone, and crosses both carotid arteries and the jugular vein.

The *stylo-hyoid* muscle lies close to the posterior belly of the digastric muscle, being a little behind and beneath it. It arises from the base of the styloid process of the temporal bone at the external surface ; and from this place it inclines downwards and forwards, to be inserted into the os hyoides at the union of the great cornu with the body. Its fibres are usually divided into two fasciculi near its insertion, for the transmission of the tendon of the digastric muscle.

The upper part of the stylo-hyoid muscle lies deeply, being covered by the sterno-mastoid and digastric muscles, and by part of the parotid gland ; the middle crosses the carotid arteries ; the insertion is comparatively superficial.

This muscle is sometimes wanting ; occasionally a second is present (stylo-hyoideus alter,—Alb.). The position too may be varied—it has been found to the inner side of the external carotid artery instead of over that vessel. ("The Anatomy and Operative Surgery of the Arteries," by R. Quain, plate 12, fig. 5.)

Fig. 160.

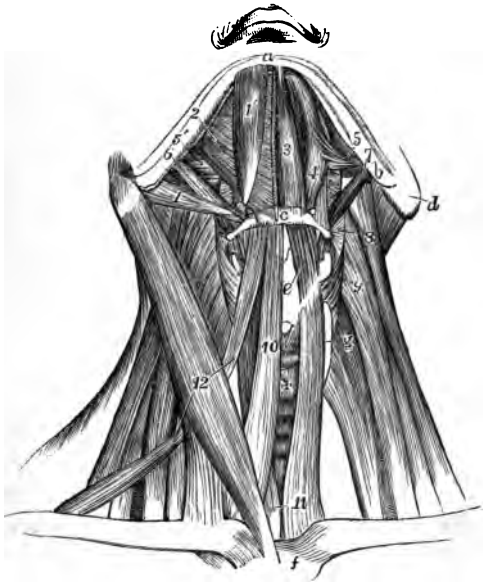


Fig. 160.—VIEW OF THE SUBMAXILLARY MUSCLES AND THE DEPRESSORS OF THE HYOID BONE AND LARYNX, FROM BEFORE. ½

On the right side, the platysma alone has been removed ; on the left side both the bellies of the digastric, the stylo-hyoid, the mylo-hyoid, the sterno-hyoid, and omo-hyoid muscles have been removed : *a*, symphysis ; *b*, angle of the lower jaw; *c*, middle of the body of the hyoid bone ; *d*, mastoid process ; *e*, thyroid cartilage ; *f*, upper part of the sternum ; *g*, lateral lobe, and +, isthmus of the thyroid gland ; above +, the front of the cricoid cartilage covered by the crico-thyroid muscle ; 1, posterior belly ; 1', anterior belly of right digastric muscle ; 2, right mylo-hyoid ; 3, left genio-hyoid ; 4, hyo-glossus ; 5, stylo-glossus ; 5', a portion of it seen on right side ; 6, stylo-hyoid of the right side ; 7, stylo-pharyngeus of the left side ; 8, placed on the levator scapulæ, points to the left middle constrictor of the pharynx ; 9, placed on the middle scalenus, points to the left inferior constrictor ; 10, right sterno-hyoid ; 11, placed on the left sterno-thyroid, points also to the lower part of the right muscle ; 12, placed on the right sterno-mastoid, points to the upper and lower bellies of the right omo-hyoid (*e*, points to the thyro-hyoid muscle).

The *mylo-hyoid* muscle arises from the mylo-hyoid ridge along the inner surface of the lower jaw, extending from the last molar tooth to the symphysis. The posterior fibres are inserted into the body of the os hyoides ; the rest, proceeding parallel to the fibres behind, join at an angle with those of the corresponding muscle, forming with them a sort of raphé along the middle line, from the symphysis of the jaw to the os hyoides. Thus the two muscles together form a floor below the anterior part of the mouth (*diaphragma oris* of Meyer).

The lower surface of the mylo-hyoid muscle is covered by the digastric muscle, the sub-maxillary gland, and the sub-mental vessels and nerve. The deep surface which looks upwards and inwards to the mouth, is in contact with the genio-hyoideus and part of the hyo-glossus and stylo-glossus muscles, the ninth and gustatory nerves, the sub-lingual gland, and the duct of the sub-maxillary gland. The posterior border alone is free and unattached, and behind it the duct of the sub-maxillary gland turns in passing to the mouth.

Fig. 161.

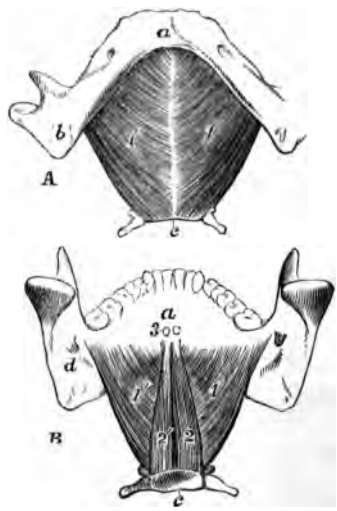


Fig. 161.—A, THE LOWER JAW AND HYOID BONE, FROM BELOW, WITH THE MYLO-HYOID MUSCLES ATTACHED.

B, THE SAME, FROM BEHIND, WITH THE MYLO-HYOID AND GENIO-HYOID MUSCLES ATTACHED. ½

a, the symphysis; *b*, the angle of the lower jaw; *c*, the lower border of the body of the hyoid bone; *d*, in B, the inferior dental foramen and upper end of the mylo-hyoid ridge: in A, 1, the left, 1′, the right mylo-hyoid muscle from below: in B, 1, the right, 1′, the left mylo-hyoid muscle from above; 2, the right, 2′, the left genio-hyoid muscle from above; 3, the cut ends of the attachment of the genio-glossi muscles to the superior genial spines.

The *genio-hyoid* muscle, a narrow muscle resting on the mylo-hyoid, and in contact with its fellow in the middle line, arises from the inferior of the two genial tubercles behind the symphysis of the jaw, and is inserted into the body of the hyoid bone.

It is in contact above with the lower border of the genio-glossus muscle.

ACTIONS.—The genio-hyoid and mylo-hyoid muscles draw the hyoid bone upwards and forwards, as happens in the first stage of deglutition. The stylo-hyoid muscle draws it upwards and backwards, and comes into action in raising the pitch of the voice. The anterior belly of the digastric muscle acts by itself like the genio-hyoid, and the posterior half like the stylo-hyoid; but when both bellies act together, they are capable of producing two movements, in one of which, when the lower jaw is fixed, the hyoid bone is elevated, and in the other, when the hyoid bone is held downwards by the depressing muscles, the digastric muscle opens the mouth by depressing the lower jaw.

B. MUSCLES OF THE TONGUE.

The tongue is a muscular organ attached posteriorly to the hyoid bone, and inferiorly to the lower jaw. It is composed partly of fibres peculiar to itself—the *intrinsic* muscles, which will be noticed in another place; partly of muscles arising from neighbouring parts—the *extrinsic* muscles about to be described.

The *genio-glossus* or *genio-hyo-glossus* muscle is fan-shaped, and is placed vertically in contact with its fellow close to the mesial plane. It arises by

a short tendon from the superior genial tubercle behind the symphysis of the jaw: from this its fibres diverge and are inserted in an extensive range, viz., those which are most inferior into the body of the hyoid bone, and a few into the side of the pharynx; those which are most superior into the tip of the tongue; and the intermediate fibres into its whole length, diverging transversely in its substance.

The external surface is in contact with the lingualis inferior, hyo-glossus and stylo-glossus muscles, the sub-lingual gland, the ranine vessels, and the nerves of the tongue.

Fig. 162.

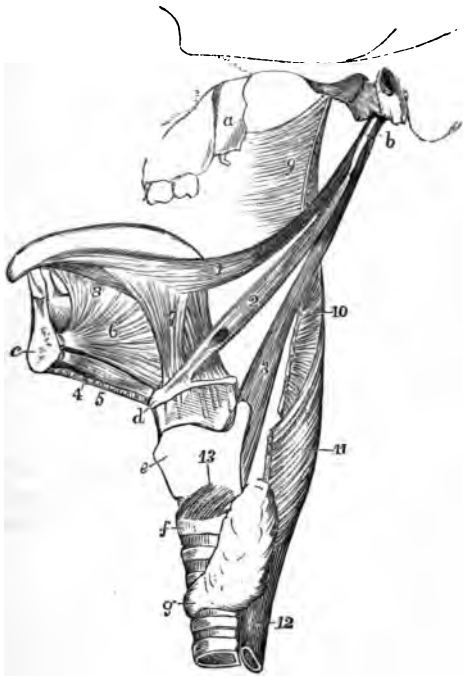


Fig. 162.—SKETCH OF A PART OF THE LEFT SIDE OF THE SKULL, THE RIGHT SIDE OF THE BODY OF THE LOWER JAW, AND THE TONGUE, HYOID BONE, LARYNX, AND TRACHEA, SHOWING THE EXTRINSIC MUSCLES OF THE TONGUE, &c. ½

a, external pterygoid process; *b*, styloid process; *c*, section of the symphysis of the lower jaw; *d*, front of the body of the hyoid bone; *e*, thyroid cartilage; *f*, front of the cricoid cartilage; between *d* and *e*, the thyro-hyoid membrane and ligament; *g*, isthmus of the thyroid gland in front of the trachea; 1, left stylo-glossus muscle; 2, stylo-hyoid; 3, stylo-pharyngeus; 4, cut edge of the mylo-hyoid; 5, genio-hyoid; 6, genio-hyo-glossus; 7, hyo-glossus; 8, lingualis inferior; 9, part of the superior constrictor of the pharynx; 10, back part of the middle constrictor; 11, inferior constrictor; 12, upper part of the œsophagus; 13, crico-thyroid muscle.

The *hyo-glossus* is a flat quadrate muscle, arising from the whole length of the great cornu of the hyoid bone, from the lateral part of the body of that bone, and from the small cornu; the fibres arising from those three sources (formerly distinguished as cerato-glossus, basio-glossus, and chondro-glossus respectively—Albinus) pass upwards to be inserted into the side of the tongue, blended with the stylo-glossus and palato-glossus muscles.

The hyo-glossus is concealed by the digastric and mylo-hyoid muscles, except at its posterior inferior angle; the deep part of the sub-maxillary gland rests on its surface, and it is crossed from below upwards by the hypo-glossal nerve, the Whartonian duct, and the gustatory nerve. It covers the genio-glossus and the origin of the middle constrictor of the pharynx, together with the lingual artery and glosso-pharyngeal nerve.

The *stylo-glossus*, the shortest of the three muscles which spring from the styloid process, arises from that process not far from its point, and from the

stylo-maxillary ligament, to which in some cases the greater number of its fibres are attached by a thin aponeurosis: passing forwards slightly downwards, it is inserted along the side and under part of the tongue as far as the tip, its fibres decussating, and becoming blended with those of the hyo-glossus and palato-glossus muscles.

This muscle lies deeply beneath the parotid gland, and is crossed by the gustatory nerve. It arises occasionally from the inner side of the angle of the lower jaw; and cases have been observed in which it was altogether absent.

Fig. 163.

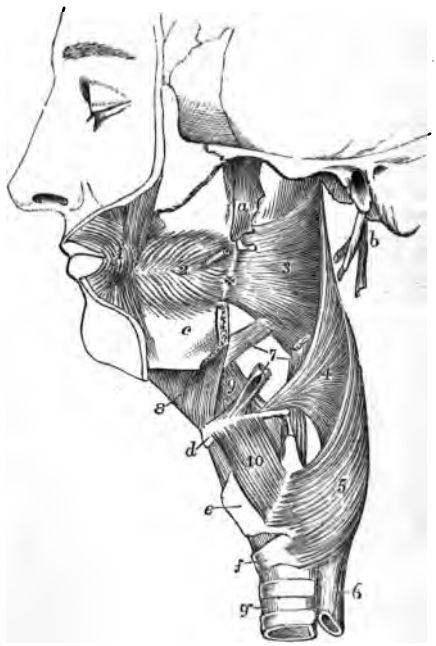


Fig. 163.—VIEW OF PART OF THE LEFT SIDE OF THE HEAD AND THROAT, TO SHOW THE DEEP MUSCLES OF THE CHEEK, PHARYNX, &c. (modified from Cloquet). ½

The pharynx has been distended by stuffing. *a*, external pterygoid process; *b*, styloid process, with short portions of the three styloid muscles attached; *c*, body of the lower jaw, which has been divided at the place where the pterygo-maxillary ligament + is attached; *d*, body of the hyoid bone; *e*, thyroid cartilage; *f*, cricoid cartilage; *g*, interval between the first and second ring of the trachea; 1, outer part of the orbicularis oris muscle; 2, buccinator; 3, superior constrictor of the pharynx; 4, middle constrictor; 5, inferior constrictor; 6, œsophagus; 7, points by three lines to the lower parts of the stylo-glossus, stylo-hyoid, and stylo-pharyngeus muscles respectively; 8, mylo-hyoid; 9, hyo-glossus, of which a small part is removed posteriorly to show the attachment of the middle constrictor; 10, thyro-hyoid.

ACTIONS.—The genio-glossus muscle has a complicated action, one part protruding and another retracting the tongue, while a third depresses the middle portion of the organ. Protrusion is effected by contraction chiefly of its posterior, and retraction by contraction of its anterior fibres, and the middle part, or nearly the whole muscle, acts as the depressor. In deglutition the stylo-glossus muscle raises the sides of the tongue spasmodically backwards and upwards, while the hyo-glossus opposes that action. In other circumstances the first muscle assists in forming a hollow, while the second tends to producing a convexity in the dorsum of the tongue.

MUSCLES OF THE PHARYNX AND SOFT PALATE.

THE PHARYNX, the dilated superior part of the alimentary tube, extending from the base of the skull to the œsophagus, presents at the sides and posteriorly a continuous wall, in great part formed and supported by distinct muscles resting in front of the vertebral column, and is open in front towards the nasal cavity, the mouth, and larynx.

The *constrictors of the pharynx* are three thin expanded muscles which invest the pharyngeal wall, overlapping one another upwards, so that the lowest is most superficial.

The *inferior constrictor* arises from the side of the cricoid cartilage, and from the oblique lateral ridge and upper and lower borders of the thyroid cartilage, and curves backwards, expanding as it proceeds, and unites with its fellow in the middle line behind the pharynx. The direction of the inferior fibres is horizontal, concealing and overlapping the commencement of the œsophagus ; the rest ascend with increasing degrees of obliquity, and cover the lower part of the middle constrictor.

The outer surface of the muscle is in contact at the side of the larynx with the thyroid body, the carotid artery, and the sterno-thyroid muscle; and from this last, where the two muscles meet on the thyroid cartilage, some fibres are continued into the constrictor. The two laryngeal nerves pass inwards to the larynx, close respectively to the upper and lower margins of this constrictor—one being interposed between it and the middle constrictor, the other between it and the œsophagus.

The inferior constrictor was described by the older anatomists as two muscles which received various names, the most appropriate of these being thyro-pharyngeus and crico-pharyngeus. In some animals they are found quite distinct from one another.

Fig. 164.

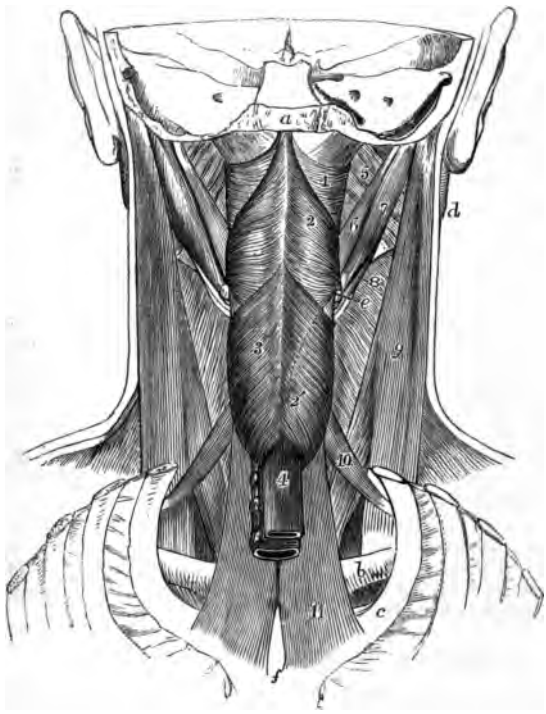


Fig. 164.—VIEW OF THE MUSCLES OF THE PHARYNX, &C. FROM BEHIND (after Bourgery). $\frac{1}{3}$

The back part of the skull, the vertebral column and back parts of the ribs are removed. *a*, cut surface of the basilar process; *b*, the clavicle; *c*, the first rib; *d*, the ramus of the lower jaw; *e*, posterior extremity of the great cornu of the hyoid bone; *f*, posterior surface of the manubrium of the sternum; 1, superior constrictor muscle of the pharynx; above it the fibrous membrane which closes the pharynx; 2, middle constrictor; 2′, a dotted line, indicating the direction of the lower part of the muscle; 3, the inferior constrictor; 4, œsophagus; 5, internal pterygoid; 6, stylo-glossus; 7, posterior belly of the digastric; 8, a portion of the stylo-hyoid surrounding the tendon of the digastric; 9, sterno-mastoid; 10, upper belly of the omo-hyoid; 11, sterno-thyroid.

The *middle constrictor*, smaller than the preceding, arises from the upper part of the great cornu of the os hyoides, from the smaller cornu, and from the stylo-hyoid ligament: its fibres diverging greatly pass back to the middle

line of the pharynx behind, the lower fibres inclining downwards beneath the inferior constrictor, the highest ascending and overlapping the superior constrictor, and the intermediate fibres running transversely.

This muscle is separated from the superior constrictor by the stylo-pharyngeus muscle and the glosso-pharyngeal nerve, while between its origin and that of the inferior constrictor the superior laryngeal nerve pierces the thyro-hyoid membrane.

Fibres of the middle constrictor have been observed to arise from the body of the os hyoides, and the thyro-hyoid ligament (syndesmo-pharyngeus of Douglas), and a few are frequently continued into it from the genio-hyo-glossus muscle. The two middle constrictors have been found connected behind to the base of the skull by a fibrous band (Albinus).

The *superior constrictor* arises by fibres attached in series from below upwards, a few to the side of the tongue, and others to the mucous membrane of the mouth, to the extremity of the mylo-hyoid ridge of the jaw, to the pterygo-maxillary ligament which separates this muscle from the buccinator, and to the lower third of the internal pterygoid plate. From these different points the fibres of the muscle curve backwards, and are mostly blended with those of the corresponding muscle along the middle line, a few ending posteriorly in the aponeurosis which fixes the pharynx to the base of the skull. The upper margin curves round the levator palati mollis and the Eustachian tube; and the space intervening between this concave margin of the constrictor and the base of the skull is closed by fibrous membrane.

In contact with the outer surface of this muscle are the internal carotid artery, with the eighth and other large nerves; the middle constrictor, which overlaps a considerable portion; and the stylo-pharyngeus, which descends to the pharynx between the two constrictors. It conceals the palato-pharyngeus and the tonsil, and is lined by mucous membrane.

The *stylo-pharyngeus*, larger and longer than the other styloid muscles, arises from the inner surface of the styloid process, near the root, and proceeding downwards and inwards to the side of the pharynx, passes under cover of the middle constrictor muscle, where it detaches some fibres to the constrictors, and gradually expanding, is connected with the palato-pharyngeus muscle, and ends in the superior and posterior borders of the thyroid cartilage.

The external surface of this muscle is, in the upper part of its extent, in contact with the styloid process, the stylo-hyoideus muscle, and the external carotid artery; in the lower, with the middle constrictor of the pharynx. Internally it rests on the internal carotid artery and jugular vein; but more inferiorly it is in contact with the mucous membrane of the pharynx. The glosso-pharyngeal nerve is close to the muscle, and crosses over it in turning forwards to the tongue.

The *salpingo-pharyngeus* (Santorini) is a small muscle, which, arising from the Eustachian tube, descends in the interior of the pharynx towards its back part, and, after joining with the palato-pharyngeus, is lost in the muscular structure of the cavity. It is often indistinct, and is frequently absent.

The Soft Palate (*velum pendulum palati*) is a movable curtain, continued backwards from the hard palate. It presents posteriorly a free pendulous margin, prolonged in the middle into a conical process, the *uvula*, and at each side into two prominent curved lines, the anterior of which, the *anterior pillar* of the fauces, descends to the side of the tongue, while the posterior line, the *posterior pillar* of the fauces, extends into the pharynx: between the two is lodged the tonsil. The constricted passage between the anterior pillars,

leading from the mouth to the pharynx, is called the *isthmus of* the fauces. The soft palate is acted on by five pairs of elongated muscles, two superior, one in the middle, and two inferior. Of the two inferior pairs of muscles, one is common to the palate and tongue, the other to the palate and pharynx.

The *palato-glossus* or *constrictor isthmi faucium* occupies the anterior pillar of the fauces. Superiorly it is anterior to all the other muscles of the velum, and its fibres are continuous with those of its fellow of the opposite side; inferiorly, it is lost on the side of the tongue.

Fig. 165.

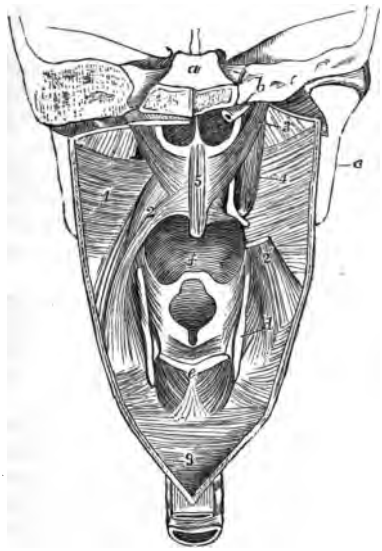


Fig. 165.—Diagrammatic View of the Muscles in the anterior wall and sides of the Pharynx, from behind. ½

The posterior wall of the pharynx has been divided by a vertical incision in the middle line, and the cut edges drawn to the side so as to expose the nasal, buccal, and laryngeal openings into the pharynx. *a*, is above the cut surface of the basilar part of the occipital bone, and below that are the posterior nares; *b*, upon the cut petrous bone, points by a line to the cartilage of the Eustachian tube of the right side; *c*, the back of the ramus of the lower jaw; *d*, the posterior border of the thyroid cartilage; *e*, middle of the upper part of the cricoid cartilage; *f*, base of the tongue in the buccal aperture above the epiglottis; *g*, lower end of the cavity of the pharynx leading down into the gullet; 1, superior constrictor of the pharynx seen from within, and part of the middle constrictor; 2, palato-pharyngeus descending to its insertion in the pharynx and thyroid cartilage; 2', the lower part of the same muscle, on the right side, the upper having been removed; 3, placed on the internal pterygoid muscle, points to the levator palati; 4, the circumflexus palati muscle on the right side descending from the navicular fossa, and winding round the pulley-like groove of the hamular process into the palate; 5, the retractor or azygos uvulæ muscles; above *e*, the transverse arytenoid muscle, and below it on each side the posterior crico-arytenoid muscle.

The *palato-pharyngeus*, occupying the posterior pillar of the pharynx, arises in the soft palate by fibres connected with those of the opposite side, and passing partly above and partly below the levator palati and azygos muscles. As the muscle descends it becomes greatly expanded, and its fibres are found extended from the posterior cornu of the thyroid cartilage, back to the middle line of the pharynx posteriorly.

The *azygos uvulæ* (Morgagni), so called from having been supposed to be a single muscle, consists of two slips arising, one on each side of the middle line, from the tendinous structure of the soft palate, and, sometimes, from the spine of the palate-plate, and descending into the uvula. The two slips are separated by a slight interval above, and unite as they descend.

The *levator palati* arises from the extremity of the petrous portion of the temporal bone, in front of the orifice of the carotid canal, and from the cartilaginous part of the Eustachian tube. Approaching the middle line as it

passes downwards and forwards, it is inserted aponeurotically into the posterior part of the soft palate, and meets its neighbour of the opposite side. In its upper part it is placed above the concave margin of the superior constrictor.

The *circumflexus* or *tensor palati* arises from the navicular fossa at the root of the internal pterygoid plate, from the outer side of the Eustachian tube, from the spine of the sphenoid, and the edge of the tympanic plate of the temporal bone. It descends perpendicularly, resting on the internal pterygoid plate, between it and the internal pterygoid muscle, and ends in a tendon which, winding round the hamular process, lubricated by a bursa, extends horizontally inwards, and terminates in the forepart of the aponeurosis of the soft palate and the posterior border of the palate bone.

Actions.—The muscles of the pharynx and soft palate are so arranged as to accomplish, in conjunction with those of the tongue and hyoid bone, the action of deglutition—that is to say, the propulsion of food into the œsophagus without any portion being permitted to pass into the nasal cavity or larynx. While the tongue near the fauces is thrown upwards and backwards by the stylo-glossi muscles, and the larynx is drawn upwards and forwards under it by muscles attached to the hyoid-bone, and by the stylo-pharyngeus muscle, so as to be both closed by the epiglottis and overlapped by the tongue, the palato-glossi muscles constrict the fauces and shut off the bolus from the mouth. The soft palate is raised and made tense by its superior muscles; the palato-pharyngei, being approximated, nearly touch one another (the uvula lying in the small interval between them), and prevent the passage of the food towards the upper part of the pharynx or the posterior nares, while at the same time they form an inclined surface for its guidance into the lower part of the pharynx. The food being thus thrown into the grasp of the constrictors of the pharynx, those muscles contract from above downwards and force it into the tube of the gullet below.

MUSCLES DEPRESSING THE HYOID BONE.

The *sterno-hyoid* muscle, a flat band of longitudinal fibres, arises variously, from the sternum and the posterior sterno-clavicular ligament, from the clavicle and that ligament, or from the clavicle only, and occasionally, to a small extent, from the cartilage of the first rib. It is inserted into the lower border of the body of the hyoid bone.

The muscle is concealed below by the sternum and the sterno-mastoid, higher up by the skin and fascia only; it lies on the sterno-thyroid and thyro-hyoid muscles, which it partly covers. The inner border approaches that of the corresponding muscle towards the middle of its extent, but is separated from it by a slight interval superiorly, and by a larger interval near the sternum; the outer margin is in contact with the omo-hyoid near the os hyoides. The muscular fibres are, in many cases, interrupted by a transverse tendinous intersection.

The *sterno-thyroid*, broader and shorter than the preceding muscle, behind which it lies, arises from the thoracic surface of the first bone of the sternum, lower down and more internally than the sterno-hyoid muscle, and ascends, diverging a little from its fellow, to be inserted into the oblique line on the ala of the thyroid cartilage.

The greater part of its anterior surface is concealed by the sternum and the sterno-hyoid muscle, as well as by the sterno-mastoid. By its deep surface it rests on the innominate vein, the lower part of the common carotid artery, the trachea, and the thyroid body. The inner margin is contiguous to the muscle of the other side in the lower part of the neck. The median incision in the operation of tracheotomy is made between the two muscles.

This muscle is often partly crossed by transverse or oblique tendinous lines. At

the upper extremity a few fibres are often found to blend with the thyro-hyoid muscle and the inferior constrictor of the pharynx.

Fig. 166.

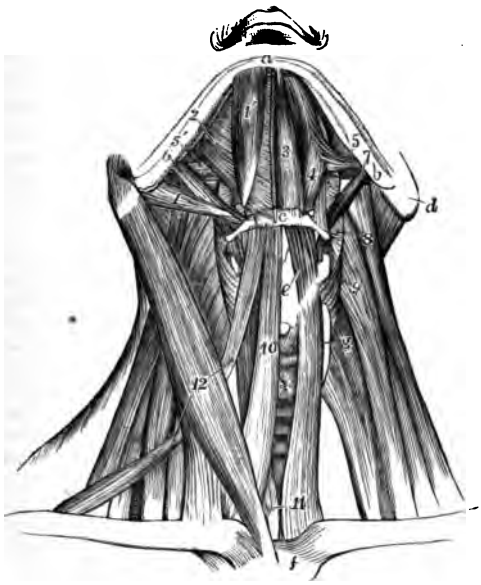


Fig. 166.—View of the Submaxillary Muscles and the Depressors of the Hyoid Bone and Larynx, from before. ½

The explanation of the references to the upper parts of the figure is given at p. 184. *c*, middle of the body of the hyoid bone; *d*, mastoid process; *e*, front of the thyroid cartilage; *f*, upper part of the sternum; *g*, lateral lobe of the thyroid gland; +, its isthmus, above which is the cricoid cartilage covered by the crico-thyroid muscle; 8, placed on the levator scapulæ, points to the left middle constrictor of the pharynx; 9, placed on the middle scalenus, points to the left inferior constrictor; 10, right sterno-hyoid; 11, placed on the left sterno-thyroid, points also to the lower part of the right muscle; 12, placed on the right sterno-mastoid, points to the upper and lower bellies of the right omo-hyoid.

The *thyro-hyoid* muscle is continued upwards from the preceding; it arises from the oblique line on the ala of the thyroid cartilage, and is inserted into the lower border of the body and great cornu of the hyoid bone, near the place where these unite.

This muscle is concealed by the sterno-hyoid and omo-hyoid, and rests on the ala of the thyroid cartilage, and on the thyro-hyoid membrane. Between that membrane and the muscle, the superior laryngeal nerve and artery are placed before entering the larynx.

The *omo-hyoid* is a long ribbon-shaped muscle, consisting of two bellies united by an intervening tendon. It arises from the upper border of the scapula, near the suprascapular notch, and occasionally from the ligament which crosses the notch. Thence it extends forwards and only slightly upwards, across the root of the neck, till it enters beneath the sterno-mastoid muscle, and then, curving rapidly, it ascends nearly vertically, to be inserted into the lower border of the body of the hyoid bone. The tendon which divides the muscle is placed beneath the sterno-mastoid muscle, and varies much in length and form in different bodies. The tendon is enclosed within the deep cervical fascia, which after forming a sort of sheath for it, is prolonged downwards and becomes attached to the sternum and the cartilage of the first rib; and by this means, as also by fascia investing the posterior belly and descending to the clavicle, the muscle is maintained in its curved position.

At its scapular origin the muscle is covered by the trapezius, in the middle of its course by the sterno-mastoid, and at its upper part by the platysma; it crosses the scaleni muscles, the cervical nerves, the sheath of the common carotid artery and jugular vein, and the sterno-thyroid and thyro-hyoid muscles.

The muscle occasionally is attached to the clavicle instead of the scapula, arising from the former bone about its middle, and in such a case the posterior belly is absent. One instance has been recorded (R. Quain) in which the posterior belly alone was present, and was connected to the hyoid bone by a band of fascia. The muscle has likewise been observed double, one slip being attached to the clavicle and the other to the normal place of origin on the scapula.

ACTIONS.—While the sterno-hyoid and omo-hyoid muscles act only as depressors of the hyoid bone, and the sterno-thyroid as a depressor of the larynx, the sterno-thyroid muscle, being a direct depressor of the thyroid cartilage, may draw down the hyoid bone when it acts in conjunction with the thyro-hyoid: the latter muscle elevates the larynx when the hyoid bone is fixed. In the act of swallowing, the hyoid bone and thyroid cartilage pass suddenly upwards and forwards, and their natural position is restored by the action of the muscles under consideration, the bone moving in the direction of the omo-hyoid muscles. In the utterance of low notes the larynx and hyoid bone descend below the natural level, in the direction in which the sternal muscles pull; while in the utterance of high notes there is little elevation of the hyoid bone, but the larynx is raised by the action of the thyro-hyoid muscles.

FLEXOR MUSCLES OF THE NECK.

The *sterno-cleido-mastoid* or *sterno-mastoid* muscle is attached inferiorly in two parts to the anterior surface of the sternum and the inner third of the clavicle. The sternal attachment is thick and rounded, tendinous in front and fleshy behind. The clavicular portion, separated from the sternal by a narrow interval, is flat, and is composed of fleshy and tendinous fibres. Those two portions become blended together about the middle of the neck into a thick and prominent muscle, which, extending upwards and backwards, is attached superiorly to the anterior border and external surface of the mastoid process, and from thence backwards into a rough ridge of the temporal, and by a thin aponeurosis into the outer part of the superior curved line of the occipital bone.

This muscle is covered for more than the middle three-fifths of its extent by the platysma. It is also crossed by the external jugular vein, and by the ascending superficial branches of the cervical plexus of nerves. It rests on part of the sterno-hyoid and sterno-thyroid muscles, and crosses the omo-hyoid muscle; in the middle part of the neck it covers the cervical plexus and the great cervical vessels, and in the upper part, the digastric and stylo-hyoid muscles: it is pierced by the spinal accessory nerve.

The sterno-cleido-mastoid is occasionally described as two muscles, under the names sterno-mastoid and cleido-mastoid. Normally, the fibres of the clavicular part run upwards for some distance internally to those of the sternal part before finally blending with them. The muscle varies much in breadth at the lower end, the variation being due altogether to the clavicular part, which is sometimes as narrow as the sternal tendon, while in other instances it extends for three inches along the clavicle. This part of the muscle may likewise, when broader than usual, be divided into several slips separated by intervals near the clavicle. A band of muscular fibres has, in a few instances, been found reaching from the trapezius to this muscle over the subclavian artery; and the margins of the two muscles have been observed in contact. In animals without a clavicle the cleido-mastoid muscle is continued into the clavicular part of the great pectoral muscle, thus forming a mastoido-humeral muscle.

The *scalenus anticus* muscle is attached superiorly to the anterior

tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ, and inferiorly by a thick flattened tendon to a rough part of the inner border and upper surface of the first rib.

Fig. 167.

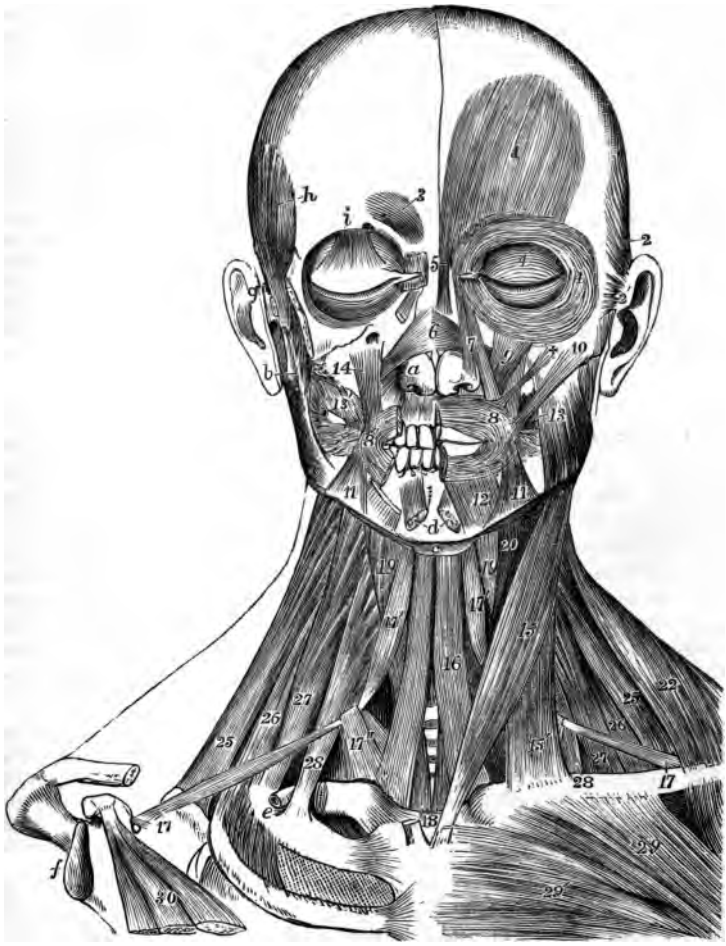


Fig. 167.—SUPERFICIAL AND DEEP VIEW OF THE MUSCLES OF THE HEAD AND NECK, FROM BEFORE. ½

The explanation of the references to the cranium and face will be found at page 172 : *c*, body of the hyoid bone ; *e*, subclavian groove of the first rib, above which the cut end of the subclavian artery is shown ; *f*, glenoid head of the scapula ; 15, sterno-mastoid muscle, its clavicular portion ; 16, sterno-hyoid ; 17, posterior, and 17′, anterior belly of the omo-hyoid ; 17″, portion of the deep fascia, which forms a loop holding down the muscle by its central tendon ; 18, on the sternum at the interclavicular notch, points by lines upwards to the lower part of the sterno-thyroid muscles ; 19, thyro-hyoid ; 20, part of the constrictors of the pharynx ; 22, clavicular part of the trapezius ; 25, levator scapulæ ; 26, scalenus posticus ; 27, scalenus medius ; 28, scalenus anticus ; 29, clavicular, and 29′, pectoral portion of the pectoralis major ; 30, pectoralis minor.

This muscle is placed deeply: in its lower part it is crossed by the posterior belly of the omo-hyoid muscle, and in its whole length it is traversed by the phrenic nerve passing obliquely from above downwards and inwards. The subclavian vein and artery pass respectively in front and behind its inferior attachment. The nerves of the brachial plexus emerge from behind its outer border above the subclavian artery. The rectus capitis anticus major arises on its inner side, the ascending cervical branch of the inferior thyroid artery lies in the groove between that muscle and the scalenus, and in front is the internal jugular vein.

The *scalenus medius* is attached superiorly to the posterior tubercles of the transverse processes of the last six cervical vertebræ; and inferiorly to a rough elevation on the first rib, extending for an inch and a half forwards from the tubercle.

In front of this muscle, between it and the anterior scalenus, are the cervical nerves and the subclavian artery; behind it are the posterior scalenus and levator anguli scapulæ muscles. It is sometimes attached to the transverse process of the atlas.

The *scalenus posticus*, smaller than the other scaleni muscles, is attached above by two or three small tendons to the transverse processes of as many of the lowest cervical vertebræ, and inferiorly by an aponeurotic tendon to the second rib, in front of the attachment of the levator costæ.

Fig. 168.

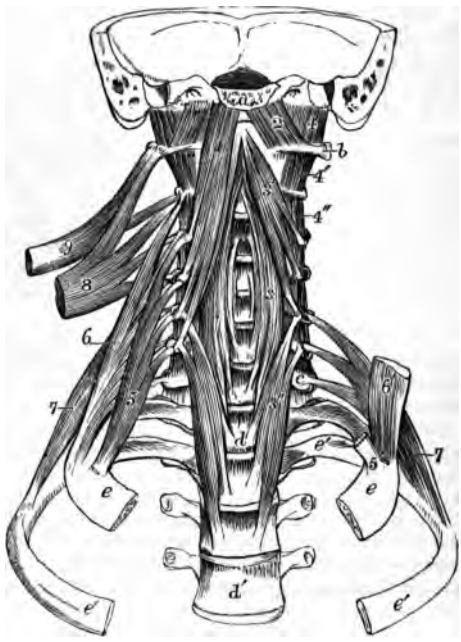


Fig. 168.—View of the Deep Muscles connected with the upper part of the Vertebral Column in front. ½

The skull has been removed in front of the basilar and mastoid processes, together with the sternum and anterior parts of the first and second ribs. *a*, cut surface of the basilar process; *b*, transverse process of the atlas; *c*, transverse process of the seventh cervical vertebra; *d*, body of the first, *d′*, of the fourth dorsal vertebra; *e*, first, and *e′*, second rib; 1, rectus capitis anticus major muscle; 2, rectus capitis anticus minor; 3, middle part, 3′, upper part, and 3″, lower part of the longus colli; 4, rectus lateralis; 4′, first pair, and 4″, second pair of intertransversales; 5, scalenus anticus of the right side; 5′, the tendon of attachment to the first rib on the left side, the rest of the muscle having been removed; 6, scalenus medius of the right side; 6′, lower portion of the corresponding muscle of the left side; 7, scalenus posticus, its superior attachments shown upon the left side; 8, upper part of the levator scapulæ drawn out from its vertebral attachments; 9, splenius colli, shown in the same manner.

The scaleni muscles are subject to some amount of variation, both in the number of their points of attachment, and in the arrangement of their fibres. A slip from the scalenus anticus sometimes passes behind the subclavian artery.

The *rectus capitis anticus major* arises from the tubercles of the transverse processes of the third, fourth, fifth, and sixth vertebræ by tendinous slips, its origin corresponding in extent to the superior attachment of the anterior scalenus muscle: it is inserted into the basilar process of the occipital bone, a little in front of the foramen magnum. The muscles of opposite sides converge as they ascend, and their mesial fibres are longest.

The anterior surface of the rectus capitis anticus major supports the pharynx, the sympathetic and vagus nerves, and the great cervical vessels. The posterior surface rests upon part of the longus colli and the rectus anticus minor.

The *rectus capitis anticus minor*, under cover of the preceding, arises from the anterior arch of the atlas, and slightly from the root of its transverse process; it is inserted into the basilar process, between the margin of the foramen magnum and the preceding muscle, half an inch from its fellow.

The *rectus capitis lateralis* is a short thick muscle arising from the upper surface of the anterior division of the transverse process of the atlas, and inserted into the rough surface beneath the jugular eminence of the occipital bone. It completes the series of intertransversales muscles.

The anterior surface of this muscle is in contact with the internal jugular vein, the posterior with the vertebral artery.

The *longus colli* muscle rests on the front of the vertebral column from the atlas to the third dorsal vertebra: it consists of three sets of fibres, of which two are oblique, and one vertical. *a.* The superior oblique portion arises, by a narrow tendinous process, from the anterior tubercle of the body of the atlas, and is inserted into the fore part of the transverse processes of the third, fourth, and fifth cervical vertebræ. *b.* The inferior oblique, the smallest part of the muscle, extends obliquely inwards from the transverse processes of the fifth and sixth cervical to the bodies of the first two or three dorsal vertebræ. *c.* The vertical part, connected by its extremities with the other divisions, is attached superiorly to the bodies of the second, third, and fourth cervical vertebræ, and inferiorly to the bodies of the three lower cervical and two or three upper dorsal vertebræ.

ACTIONS.—The sterno-cleido-mastoid muscles, and in a less degree the scaleni muscles, bend forwards the head and neck towards the sternum. The sterno-mastoid muscles, when acting in concert with the extensor muscles of the head, assist in the extension, and project the chin. When the sterno-mastoid muscle of one side only is in action, the head, while it is slightly flexed, is inclined laterally to the side on which the muscle contracts, and rotation is produced, by which the face, and especially the chin, is directed towards the opposite side. This is the position which occurs in wry-neck, depending upon an unequal action of the opposite sterno-mastoid muscles.

The scalene muscles, when the vertebral column is fixed, act as elevators of the ribs, and by many are considered as constant aids in the movement of inspiration. It seems certain that when the head is fixed the sterno-mastoid muscles also assist in forcible inspiration by the elevation of the sternum and clavicles.

FASCIÆ OF THE HEAD AND NECK.

The SUPERFICIAL FASCIA is little developed on the head and neck, and is in great measure blended with structures described under other names. A

layer of considerable firmness intervenes between the aponeurosis of the occipito-frontalis muscle and the skin, uniting them together: from the surface of the occipital part of the muscle it becomes continuous with a superficial covering of the posterior muscles of the neck, and on either side of the epicranial aponeurosis it descends over the temporal fascia, and contains between its laminæ the external muscles of the ear, with the superficial temporal vessels and nerves.

In the face, the fibres of the superficial muscles are frequently so much incorporated with the skin, that in many parts there is no distinct intervening layer of superficial fascia; and over most of the face the subcutaneous fat breaks up the fascia to a great extent. On the side of the neck, where a representative of the superficial fascia is found in the tissue containing the platysma myoides muscle, it is thin, and has embedded in it the external jugular vein and some superficial nerves.

The DEEP FASCIÆ of the head and neck deserve special attention, as they give investments of considerable strength, and serve to mark the separation between several important organs.

The *temporal fascia* is a structure of an aponeurotic nature, which covers the temporal muscle above the zygoma, and gives extensive attachment to its fibres of origin. It springs inferiorly from the upper border of the zygomatic arch, and is attached in the rest of its circumference to the posterior border of the malar bone and to the temporal ridge on the frontal, parietal, and temporal bones. It is divided below into two layers, one of which is attached to the outer and the other to the inner surface of the zygoma; and in this situation there is deposited between its layers a quantity of fat, the absorption of which is one cause of the hollowness of the temples in emaciated persons. This dense fascia is separated from the integuments by the layer of thin membrane descending from the epicranial aponeurosis, and by the auricular muscles; and from the temporal muscle below, by a deeper layer of fat.

The *cervical fascia* (named also proper or deep cervical) passes forwards from the anterior border of the trapezius muscle over the sides and front of the neck beneath the platysma myoides. Posteriorly it is continuous with the layers of connective tissue with which the trapezius and deeper muscles are invested; it extends over the posterior triangle of the neck, viz., the space bounded by the trapezius and sterno-mastoid muscles and the clavicle: at the posterior border of the sterno-mastoid it divides into two layers, which form an investment for that muscle; these unite again at the anterior border into a membrane which passes forwards across the middle line, and covers the area bounded by the middle line, the border of the jaw, and the sterno-mastoid muscle, and called the anterior triangle. In the posterior triangle the fascia is attached inferiorly to the clavicle, and near that bone is perforated by the external jugular vein, which in the previous part of its course lies superficial to the membrane. In the anterior triangle it is bound superiorly to the border of the jaw in front, and further back is continued over the masseter muscle (*masseteric fascia*), and the parotid gland, which it closely invests (*parotid fascia*); it likewise sends upwards a process on the posterior and deep surfaces of the parotid gland; and a strong band of this process, known under the name of the *stylo-maxillary ligament*, extends from the styloid process to the angle of the jaw, so as to keep the parotid and submaxillary glands distinct, even although one or both of them may be greatly enlarged.

In the front of the neck the fascia is attached to the hyoid bone, and, becom-

ing stronger as it descends, it splits, a little below the level of the thyroid body, into two distinct layers. Of these the more superficial and weaker, guided by the sterno-mastoid muscles, is fixed to the sternum and the interclavicular ligament; whilst the stronger layer, lying under the former, and closely covering the sterno-hyoid and sterno-thyroid muscles, is attached to the deeper surface of that bone. These layers materially assist in closing the cavity of the chest, above the sternum: between them there exists a quantity of loose connective tissue and fat, and sometimes a small lymphatic gland.

Continuous with the deeper of those two layers, a deep layer is found likewise in the posterior triangle, investing the posterior belly of the omo-hyoid muscle, and binding it down to the clavicle and first rib. Still deeper than the processes now described is a layer which lies behind the depressor muscles of the larynx, investing the thyroid body, and extending thence on the trachea and large vessels at the root of the neck down to the fibrous layer of the pericardium.

Continuous with the deep processes of the cervical fascia is the *common sheath of the large cervical bloodvessels*, an envelope of fascia enclosing the carotid artery and jugular vein with the pneumogastric nerve. A thin fibrous septum intervenes between the artery and vein, thus completing a separate sheath for each.

The layer of fascia descending on the prevertebral muscles, and intervening between them and the pharynx and œsophagus, is called the *prevertebral fascia.*

MUSCLES OF THE UPPER LIMB.

Between different parts of the head and trunk on the one hand, and the shoulder and humerus on the other, certain muscles pass which attach the upper limb to the body, and which, though situated mainly on the trunk, and often described along with its muscles, have so intimate a connection, both in their structure and uses, with the limb, that they may with greater propriety be treated of along with the muscles of that part. The muscles referred to are, posteriorly, the trapezius, latissimus dorsi, levator anguli scapulæ, and the rhomboidei; and, anteriorly, the two pectoral muscles, the subclavius, and the serratus magnus. Along with these might also be mentioned the clavicular part of the sterno-cleido-mastoid muscle and the omo-hyoid; but as these last have important relations with parts situated in the neck, they are more conveniently described among the muscles of that region.

Fig. 169.—Superficial Muscles of the Trunk, Shoulder and Hip, viewed from behind. $\frac{1}{5}$

a, external occipital protuberance; *b*, acromion of the scapula; *c*, crest of the ilium; 1, trapezius; 1′, oval tendon of the two muscles in the upper dorsal and lower cervical region; 1″, triangular tendon of insertion; 2, latissimus dorsi; 2′, 2′, its costal origins and its direct origin from the crest of the ilium; 1, 2′, *a*, the superficial layer of the lumbar aponeurosis; 3, sterno-mastoid; 4, deltoid; 5, infraspinatus; 6, teres minor; 7, teres major; 8, rhomboideus major; below this on the left side is seen a triangular space bounded by the rhomboid, trapezius, and latissimus dorsi muscles, in which, when the arm is depressed, as on the right side, a part of the seventh rib is usually felt; on the left side, the arm and shoulder being elevated, the space is enlarged so as to show a part of the sixth and seventh ribs; 9, back part of the external oblique muscle of the abdomen; between 9 and 2′, a small part of the internal oblique; 10, part of the gluteus medius covered by the fascia lata; 11, gluteus maximus; 12, gracilis; 13, small part of the adductor magnus; 14, semitendinosus; 15, biceps; 16, fascia lata covering the vastus externus.

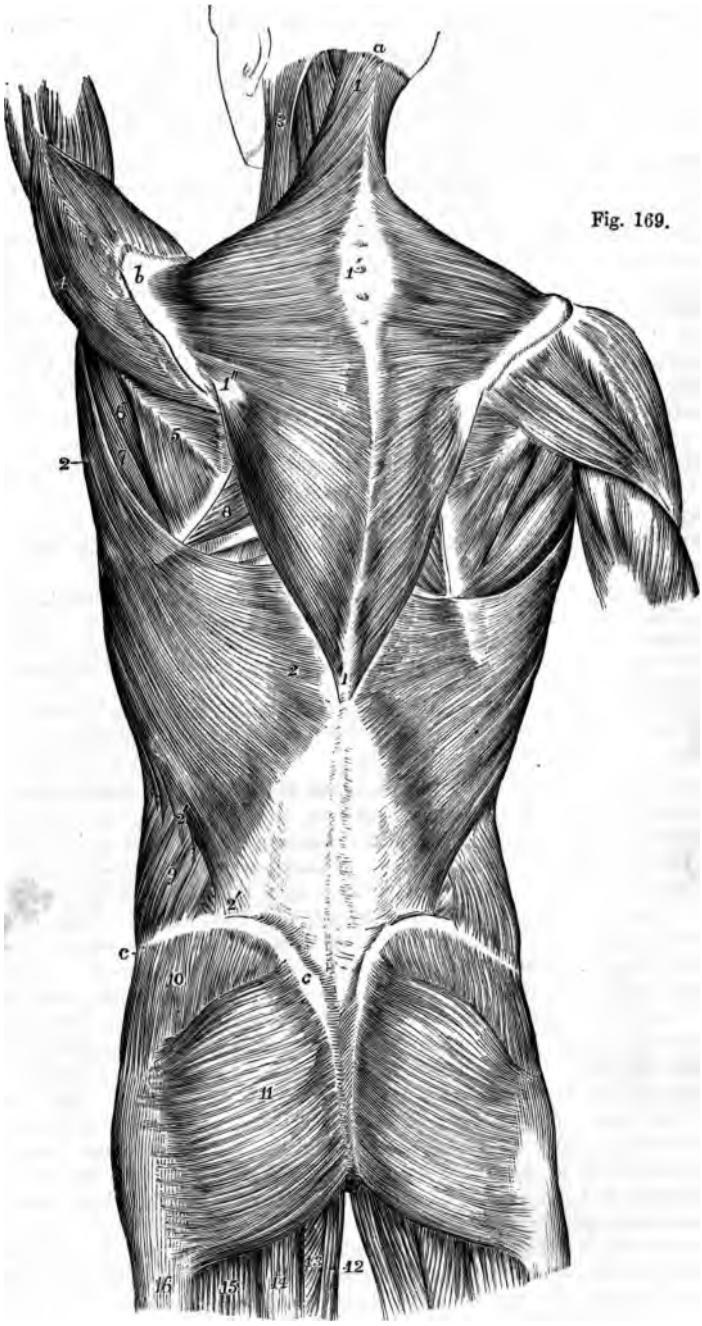


Fig. 169.

MUSCLES ATTACHING THE UPPER LIMB TO THE TRUNK POSTERIORLY.

The *trapezius* muscle (cucullaris) arises by a thin aponeurosis from the protuberance of the occipital bone, and the inner third of its superior curved line, from the ligamentum nuchæ, and from the spines of the last cervical and all the dorsal vertebræ, as well as from the supraspinous ligaments. From this extended line of origin the fibres converge to their insertion: the superior fibres, descending and turning forwards in the neck, are inserted into the external third of the clavicle at its posterior border; the succeeding fibres pass transversely to the inner border of the acromion process and upper border of the spine of the scapula, while the inferior fibres ascending terminate in a flat tendon which glides over the triangular area at the base of the spine of the scapula, and is inserted into the rough mark at the root of the spine. The greater part of the origin becomes immediately muscular, but opposite the seventh cervical spine, and for the distance of several vertebræ above and below that point, a flat tendon extends outwards, widest at the middle of the space, and narrowing towards the upper and lower ends, so that the aponeuroses of the two muscles taken together have an elliptical form. The fibres of origin from the occipital bone have no tendinous lustre, and resemble rather a strong fascia. The muscles of the two sides, regarded together, have the form of a four-sided figure, or shawl, pointing downwards: hence the names which have been given to it.

The trapezius is superficial in its whole extent: it covers the splenius, the greater part of the complexus above the splenius, the levator anguli scapulæ, the rhomboidei, the supraspinatus, and small portions of the infraspinatus, latissimus dorsi, and lumbar aponeurosis. The spinal accessory nerve, and the superficial cervical artery, pass into it from its deep surface.

The trapezius is not unfrequently shorter than above described, and the number of dorsal vertebræ with which it is connected is sometimes diminished even to six or seven.

The *latissimus dorsi* arises by tendinous fibres from the spinous processes of the six or seven lowest dorsal vertebræ, and from the posterior layer of the lumbar aponeurosis, through the medium of which it is attached to the lumbar and upper sacral spines and back part of the iliac crest; it also arises by fleshy fibres for an inch or more from the iliac crest in front of the outer margin of the lumbar aponeurosis, and from the last three or four ribs by fleshy slips which interdigitate with the attachments of the external oblique muscle. The fibres at the upper part are the shortest, and pass almost horizontally outwards over the lower angle of the scapula, from which they frequently receive a fasciculus of fleshy fibres; those lower down become longer and incline from below upwards, gradually increasing in the degree of their obliquity; finally, those which are attached to the ribs ascend almost vertically. By this convergence the fibres of the muscle come to form a narrow band of some thickness, which, accompanying the teres major towards the axilla, winds round the lower and outer border of that muscle so as finally to be placed in front of it. At this place it terminates in a flat tendon of about two inches in length, which generally becomes adherent to that of the teres major, but is again detached from it at the insertion. The tendon is inserted in the floor of the bicipital groove of the humerus, a little higher than the insertion of the teres major. From this twisting of the muscle upon itself the anterior surface of the tendon is continuous with the posterior surface of the rest of the muscle.

Fig. 170.—Superficial View of the Muscles of the Trunk, Shoulder and Hip (after Bourgery). ¼

o, occipital protuberance; C, transverse process of the atlas; D, first dorsal vertebra; L, first lumbar vertebra; S, upper piece of the sacrum; Co, first piece of the coccyx; *a*, acromion; *b*, base of the scapula; *i*, crest of the ilium; 1, upper and back part of the sterno-mastoid muscle, spreading from the mastoid process to the superior curved line of the occipital bone; 2, splenius, levator anguli scapulæ, and other deep muscles; 3, 3′, upper and lower ends of the trapezius muscle; 3′, triangular tendon attached to the base of the spine of the scapula; +, half of the oval tendon belonging to the two trapezius muscles in the lower cervical and upper dorsal region; 4, 4, latissimus dorsi; 4′, 4″ line along which the latissimus dorsi takes origin from the lumbar fascia; 5, infraspinatus; 6, teres minor; 7, teres major; 8, middle or acromial part of the deltoid; 9, hinder part of the external oblique muscle of the abdomen; 10, gluteus medius, covered by the aponeurosis of the fascia lata; 11, 11, line of origin of the gluteus maximus from the posterior part of the ilium to the coccyx; 11′ its insertion into the fascia lata over the trochanter major; 11″, a part of its insertion into the femur; 12, biceps; 13, semitendinosus; 14, adductor magnus; 15, gracilis.

The latissimus dorsi is superficial, except at its origin from the dorsal vertebræ, where it is covered by the trapezius, and at its insertion, where it dips into the axilla. It rests on part of the rhomboideus major and infraspinatus, on the teres major, serratus posticus inferior, vertebral aponeurosis, external intercostal muscles, and the posterior borders of the external and internal oblique muscles.

Between the adjacent borders of the latissimus dorsi, trapezius, and rhomboideus major, there is left, when the scapula is drawn forward, a triangular area, in which a portion of one or two ribs and an intercostal space becomes superficial; this is taken advantage of for the purpose of auscultation.

Fig. 170.

The number of dorsal vertebræ to which the latissimus dorsi is attached varies from four to seven or eight, and the number of the costal attachments is also inconstant. A muscular band is sometimes seen to stretch from this muscle across the axilla to its anterior part, where it terminates variously, in the tendon of the greater pectoral, in the coraco-brachialis muscle, or in the fascia.

Fig. 171.

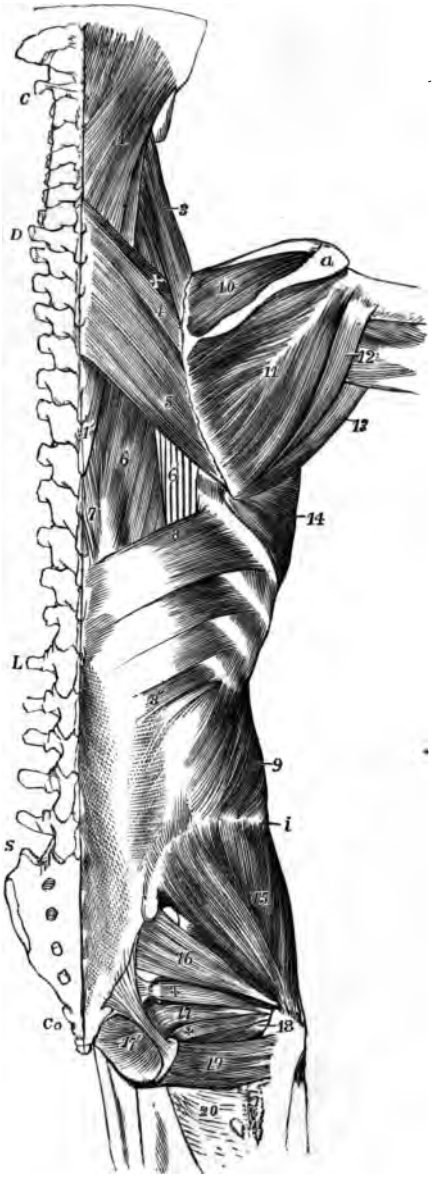


Fig. 171.—Deeper View of the Muscles of the Trunk, Shoulder and Hip (after Bourgery). ⅛

The trapezius, latissimus dorsi, deltoid, gluteus maximus and external oblique muscles have been removed. The bones are lettered as in the preceding figure.

1, splenius capitis and splenius colli; 1′, its lower end; 2, upper part of the complexus near its insertion; 3, levator anguli scapulæ; 4, rhomboideus minor; above it +, a part of the serratus posticus superior; 5, rhomboideus major; 6, part of the longissimus dorsi; 6′, part of the tendons of insertion of the sacro-lumbalis; 7, part of the spinalis dorsi; 8, upper, and 8′, lower part of the serratus posticus inferior; 9, obliquus abdominis internus; 10, supraspinatus; 11, infraspinatus; 12, placed upon the long head of the triceps, points to the teres minor; 13, teres major; 14, serratus magnus; 15, gluteus medius; 16, pyriformis; 17, portion of the obturator internus; + and +, superior and inferior gemelli; 17′, the pelvic portion of obturator internus; 18, the tendon of the obturator externus passing to its insertion; 19, quadratus femoris; 20, upper part of the adductor magnus.

The *rhomboidei* muscles are placed parallel to one another, and are separated only by a slight interval. They are extended obliquely from the spinous processes of the lower cervical and upper dorsal vertebræ to the base of the scapula.

The *rhomboideus minor*, a comparatively narrow muscle, arises from the spinous processes of the seventh cervical and first dorsal vertebræ and from the ligamentum nuchæ. It inclines

downwards and outwards, and is *inserted* into the base of the scapula opposite the triangular surface at the commencement of the spine.

The *rhomboideus major*, three or four times broader than the preceding muscle, arises from the spinous processes of the four or five upper dorsal vertebræ, and their interspinous ligaments, and is inserted into that part of the base of the scapula which is included between the spine and inferior angle. Some of the fibres, instead of being fixed to the bone, end in a tendon which is connected to the scapula above the lower angle; and, in consequence of this arrangement, the muscle may, in part, be separated from the bone without division of its muscular or tendinous fibres.

The greater part of the rhomboidei muscles is covered by the trapezius, a small angular portion of the rhomboideus major only lying superficially in the interval between the trapezius and latissimus dorsi; the extent of this portion varies with the position of the scapula, being increased when the arm and shoulder are raised from the side. The rhomboidei cover the greater part of the serratus posticus superior, and the posterior scapular artery descends on their deep surface.

The *levator anguli scapulæ* arises by slightly tendinous slips from the posterior tubercles of the transverse processes of the first three or four cervical vertebræ, between the splenius and scaleni muscles, and forms an elongated fleshy mass which is inserted into the portion of the base of the scapula intervening between the spine and superior angle.

The number of vertebral attachments of the levator anguli scapulæ is subject to some variation. A slip has been observed to extend to it from the mastoid process of the temporal bone (Theile), and from the second rib (Meckel). It often appears as a divided muscle, the parts connected with the several vertebræ remaining separate, even to the place of insertion. In quadrupeds it is united with the serratus magnus, so as to form a single muscle.

MUSCLES ATTACHING THE UPPER LIMB TO THE TRUNK ANTERIORLY.

The *pectoralis major* muscle arises from the sternal half, or a little more, of the clavicle; from the anterior surface of the sternum, extending as far down as the insertion of the cartilage of the sixth rib; from the cartilages of the first six ribs, and also the bony part of the sixth rib; and from the aponeurosis of the external oblique muscle of the abdomen. Springing from this extensive origin its fibres form a thick mass, and, converging to some extent, are inserted by a tendon of considerable breadth into the ridge which forms the outer margin of the bicipital groove of the humerus, and thence downwards as far as the deltoid impression. The muscular fasciculi converge towards the axilla, and the muscle with its tendon is folded at the axillary border, so that the clavicular part remains in front, while the pectoral part passes behind. The arrangement is such that at last the folded tendon of the muscle is inserted into the humerus in two nearly parallel lines which are connected below. The fibres of the clavicular part, in the order of their origin from without inwards, are prolonged into the anterior or outer line of insertion in order from above downwards. The pectoral part of the muscle is inserted into the inner or posterior line; the fibres which have the highest origin being the lowest at their insertion, and those which arise lower in succession from the chest passing higher and higher to their insertion on the humerus. Further

Fig. 172.

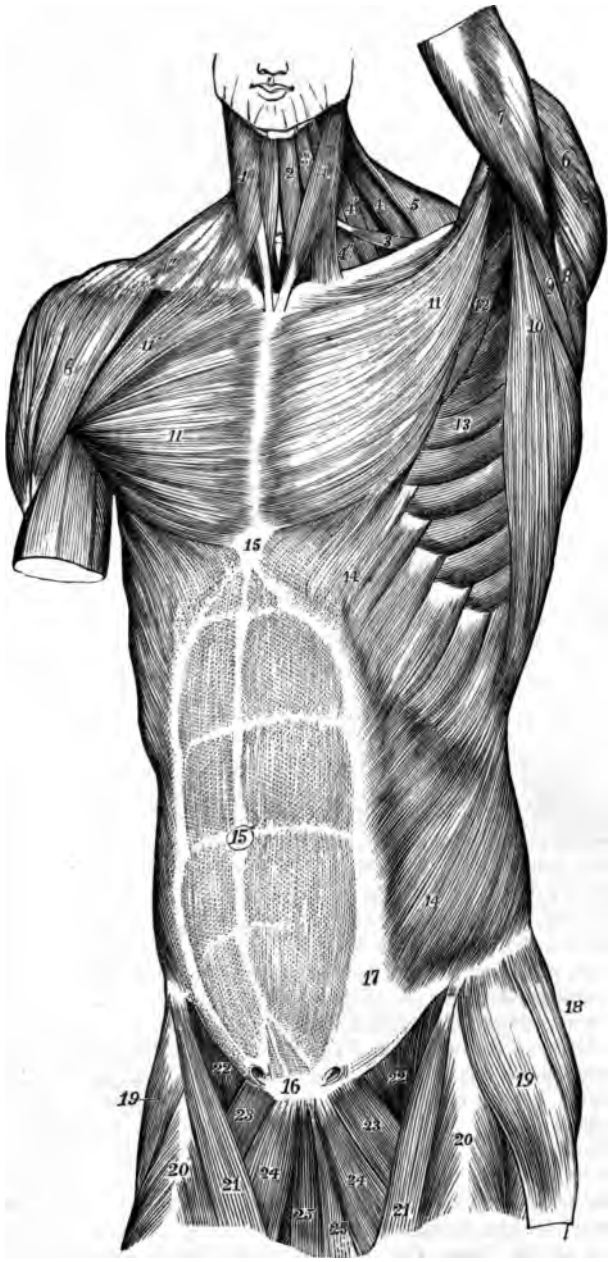


Fig. 172.—Superficial view of the Muscles of the Trunk, from before. $\frac{1}{8}$
1, sterno-mastoid of the left side; 1′, 1″, platysma myoides of the right side; 2, sterno-

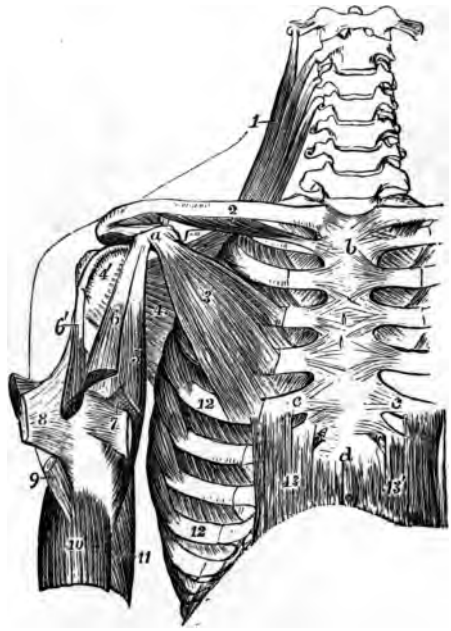
hyoid; 3, upper, 3′, lower belly of the omo-hyoid; 4, levator anguli scapulæ; 4′, 4″, scalene muscles; 5, anterior part of the trapezius; b, deltoid; 7, upper part of the triceps brachii in the left arm; 8, teres minor; 9, teres major; 10, latissimus dorsi; 11, pectoralis major; 11′, on the right side its clavicular portion; 12, part of the pectoralis minor; 13, serratus magnus; 14, external oblique muscle of the abdomen; 15, placed on the xiphoid cartilage at the upper end of the linea alba; 15′, is placed on the umbilicus; 16, is placed over the symphysis pubis, and at the lower end of the linea alba, above 16, the pyramidal muscles are seen shining through the abdominal aponeurosis; 15 to 17, the linea semilunaris at the outside of the rectus muscle, the transverse tendinous lines of which are seen through the abdominal aponeurosis; 18, part of the gluteus medius; 19, tensor vaginæ femoris; 20, rectus femoris; 21, sartorius; 22, femoral part of the iliacus and psoas; 23, pectineus; 24, adductor longus; 25, gracilis. On either side of 16, the external adominal ring is indicated.

it is to be observed that the tendon of insertion of the pectoral part of the muscle passes higher than that of the clavicular part, extending as far as the base of the great tuberosity, where it sends a thin prolongation across the bicipital groove, and an offset to the head of the humerus. The lowest inserted portion of the muscle is closely united with the insertion of the deltoid. From its inferior margin an offset is prolonged to the fascia of the arm.

The folded inferior border of the pectoralis major forms the anterior margin of the axilla; the superior runs parallel with that of the deltoid muscle, from which it is separated only by a slight interval which becomes wider towards the clavicle, and in which

Fig. 173.—View of some of the deeper Muscles of the Shoulder and Trunk, from before. $\frac{1}{3}$

Fig. 173.



On the right side the pectoralis major and external oblique muscles have been removed. *a*, coracoid process of scapula; *b*, manubrium of sternum; *c*, *c*, cartilage of the fifth ribs; *d*, ensiform portion of the sternum; 1, upper part of the levator scapulæ muscle; 2, on the middle of the clavicle, points to the subclavius muscle; 3, pectoralis minor; 4, subscapularis; 4′, its insertion into the lesser tuberosity of the humerus; 5, coraco-brachialis; 6, coracoid, and 6′, glenoid head of the biceps brachii, both cut short near the place where they unite into one muscle; 7, on the tendon of the latissimus dorsi, points by a line to the tendon of the teres major, both passing to their insertion inside the bicipital groove, both cut short; 8, folded tendon of the pectoralis major, cut short; 9, inserted portion of the deltoid; 10, upper part of the brachialis anticus at its origin, embracing the insertion of the deltoid; 11, part of the middle and inner head of biceps; 12, on the fifth and eighth ribs, points to the insertion of the serratus magnus; 13, 13′, recti abdominis.

run the cephalic vein and the humeral branch of the acromio-thoracic artery. The anterior surface is subcutaneous in the greater part of its extent, being covered only by some of the fibres of the platysma myoides and by the mamma. The posterior surface rests chiefly on the pectoralis minor, and externally and internally to that muscle forms the anterior wall of the axilla.

The tendinous fibres of origin of opposite sides sometimes decussate in front of the sternum, and occasionally the fleshy fibres also of opposite sides come into contact. In some instances additional muscular slips take origin from the aponeurosis of the external oblique muscle, and in others the lower part of the muscle presents considerable deficiency.

The *pectoralis minor* arises from the upper margins and external surfaces of three ribs near their cartilages—usually the third, fourth and fifth—and from the neighbouring parts of the intercostal aponeurosis. Its fibres converge to a narrow tendon, which is inserted into the anterior half of the inner border and upper surface of the coracoid process, in contact with the conjoined origin of the coraco-brachialis and biceps muscles.

This muscle is covered by the pectoralis major, and forms a part of the anterior wall of the axilla. When the arm is much raised a portion of the muscle is seen below the outer margin of the pectoralis major.

The *subclavius* muscle arises by a short thick tendon from the first costal arch at the junction of the rib and cartilage, close to the costo-clavicular ligament. From this tendon its fibres pass outwards and upwards, forming

Fig. 174.

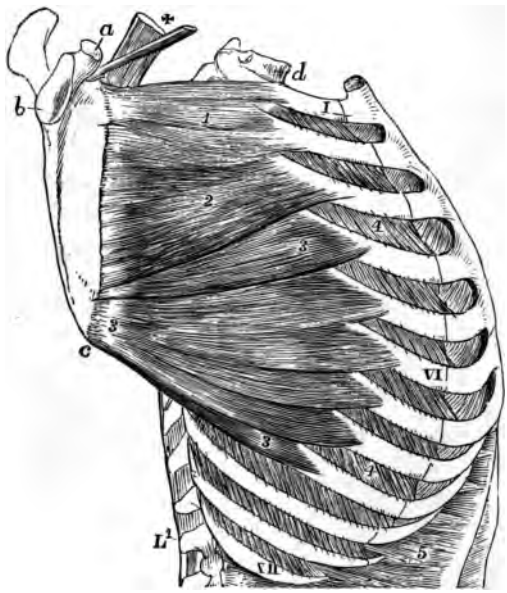


Fig. 174.—Lateral view of the Trunk, showing in a deep dissection a view of the Serratus Magnus Muscle. $\frac{1}{5}$

a, coracoid process of the scapula; *b*, glenoid cavity; *c*, lower angle; *d*, first dorsal vertebra; 1, VI, XII, the first, sixth, and twelfth ribs; 1, upper portion of the serratus magnus attached to the first and second ribs; 2, second or middle portion attached chiefly to the third rib; 3, lower or fan-shaped portion attached to the ribs from the fourth to the ninth; 4, external intercostal muscles marked in the third and ninth spaces; 5, upper costal origins of the transversalis abdominis; ×, scapular extremities of the levator scapulæ and omo-hyoid muscles.

a rounded belly, which is inserted into the groove along the inferior surface of the clavicle, extending as far as the recess between the conoid and

trapezoid parts of the coraco-clavicular ligament. It is covered in front by the costo-coracoid membrane or fascia.

The *serratus magnus* muscle, placed upon the upper and lateral part of the thorax, between the ribs and the scapula, is attached anteriorly by nine fleshy angular slips to the first eight ribs, two of these being connected with the second rib; it also derives some fibres from the aponeurosis covering the upper intercostal spaces. Posteriorly, the muscle, considerably narrowed, is attached to the line in front of the base of the scapula, and at the upper and lower angles of the bone into the flat surfaces which are excluded from the fossa of the subscapular muscle. The fibres are arranged in three sets, thus—*a*. Those from the first and second digitations form a thick bundle which terminates on the flat area in front of the upper angle of the scapula; *b*. those of the third and fourth digitations, but especially the first of these, which is the inferior digitation of the second rib, spread out into a triangular layer, the thinnest part of the muscle, and are attached along the line in front of the base of the scapula, extending from the place of insertion of the preceding part nearly to the lower angle of the bone; *c*. the remaining five or six digitations converge in the form of a fan, and terminate in a thick mass, which is attached posteriorly to the flat surface in front of the lower angle of the scapula.

By its deep surface, the serratus magnus rests on the upper ribs, the intercostal muscles, and part of the serratus posticus superior. Its outer surface is in contact posteriorly with the subscapular muscle, and forms anteriorly the internal wall of the axilla, being subcutaneous in the lower part of its extent.

Not unfrequently the number of digitations, and the number of the ribs with which the muscle is connected, are greater than above described. Occasionally the attachment to the first rib is wanting; and examples are recorded of the absence of the middle part of the muscle.

Actions.—Considered with reference to the movements of the limb upon the trunk, the upper part of the trapezius, the levator scapulæ, and the rhomboid muscles are elevators of the shoulder; the lower part of the trapezius, the pectoralis minor and the subclavius are depressors; the serratus magnus as a whole carries forward the base of the scapula, and the rhomboidei draw it back; the latissimus dorsi and pectoralis major depress the humerus and carry it towards the middle line, behind or in front, according as the one or other muscle is in action.

More particularly, the superior fibres of the *trapezius* elevate the clavicle; the succeeding fibres acting on the acromion have also some elevating action, but tend rather to carry back the scapula towards the spine; the inferior part of the muscle acting upon the spine of the scapula would of itself depress that bone while it carried it inwards towards the dorsal spines, but acting in concert with the upper two-thirds of the muscle, a rotation is produced in the scapula round a central point in such a manner that while the whole bone, and more especially the acromion, is raised and carried towards the dorsal spines, the upper angle of the scapula is somewhat depressed and carried inwards, while the lower angle is carried outwards and elevated.

The *levator scapulæ*, in elevating the superior angle of the scapula, counteracts in some degree the rotating action of the trapezius, and this is further effected by the rhomboid muscles, more especially the greater, which, as its main attachment is near the inferior angle of the scapula, necessarily tends to raise that part and bring it nearer to the dorsal spines. In this manner when the trapezius, levator, and rhomboid muscles act together, the scapula is raised without rotation, and its base is carried at the same time inwards towards the dorsal spines.

The *subclavius*, by depressing the clavicle, diminishes the space between that bone and the first rib, and may probably act principally as a support to the sterno-clavicular articulation.

The *pectoralis minor*, in bringing the coracoid process downwards and forwards, tends to throw the lower angle of the scapula backwards.

The *serratus magnus* muscle, by withdrawing the scapula from the spinal column, enables the arm when raised from the shoulder to be still farther outstretched, as in the movement termed extension in fencing. It comes powerfully into action in all movements of pushing; it likewise combines with the trapezius in rotating the scapula.

The *latissimus dorsi* carries the elevated arm downwards and backwards, rotating it at the same time inwards, so as to make the palm look backwards, thus accomplishing such a movement as is made by the arm in swimming. By passing over the angle of the scapula it binds that process to the trunk, preventing its projection backwards; and by being folded round the outer border of the scapula, it limits the projection outwards of the same angle when the arm is raised.

The *pectoralis major* muscle, while it combines with the latissimus dorsi in depressing the humerus from the raised position, opposes that muscle by drawing the limb forwards. It is placed upon the stretch when the arms are thrown backwards, and is most shortened when they are folded across the chest.

Considered as acting on the trunk from the upper limb in a fixed condition, these muscles have chiefly the following effect:—They all tend to draw the trunk of the body towards the limb, as in climbing, or other like efforts. The latissimus dorsi, if acting on both sides, carries the body upwards and forwards, as in the use of crutches, or in throwing a somersault from the hands backwards. The pectoral and latissimus dorsi muscles are also muscles of forced inspiration, tending to raise and dilate the ribs, more especially when the arms are elevated. The upper parts of both trapezii muscles acting on the occipital bone aid the sterno-mastoid muscle in throwing forward the chin; and if one muscle only acts, it aids in rotating the head.

MUSCLES OF THE SHOULDER.

The *deltoid* is a coarsely fasciculated muscle, extending from the most prominent part of the shoulder down a third of the upper arm. It arises by a broad margin in three portions, an anterior from the external third of the clavicle, a middle from the outer edge of the acromion, and a posterior from the lower border of the spine of the scapula as far back as the triangular surface at the inner end of that portion of the bone, and the fasciculi from the extended origin, converging as they descend, are inserted by a comparatively narrow but thick extremity into the triangular rough surface above the middle of the humerus, on its outer side. This rough surface receives the name of the deltoid impression.

At its posterior part the origin of the deltoid is thin and tendinous, and in the rest of its extent fibrous septa dip down between the coarse muscular fasciculi. At the insertion it is tendinous on the deep surface, and fibrous septa also project upwards from thence into the substance of the muscle. The muscular fibres are arranged pennately round those septa with such regularity as to have suggested to Albinus the subdivision of the muscles into seven parts, four of them broad above and narrow below, and three intercalated between those parts, which are broad below and narrow above. (Albinus, Histor. Muscul. Hom., p. 423.)

At the posterior border of the deltoid, the aponeurosis covering the infraspinatus muscle divides into two thin layers, of which one covers the muscle superficially, and the other lines its deep surface. At its anterior border this muscle is in contact with the pectoralis major, the cephalic vein lying between them. In immediate contact with the deep surface is the large bursa, which separates this muscle and the acromion from the shoulder joint and the muscles supporting it. The deltoid muscle covers the origins of the biceps, coraco-brachialis, and long head of the triceps, and the insertions of the subscapularis, supraspinatus, infraspinatus and teres minor muscles, as also the circumflex vessels and nerve.

The *subscapularis* muscle arises from all the venter of the scapula, with the exception of the neck of the bone and the spaces occupied by the serratus

magnus; it is inserted tendinously into the small tuberosity of the humerus, and by fleshy fibres into the bone for a short distance lower down. Tendinous septa, attached to the ridges of the subscapular fossa, pass outwards in the origin of the muscle, and others are prolonged inwards from the tendon of insertion.

Fig. 175.

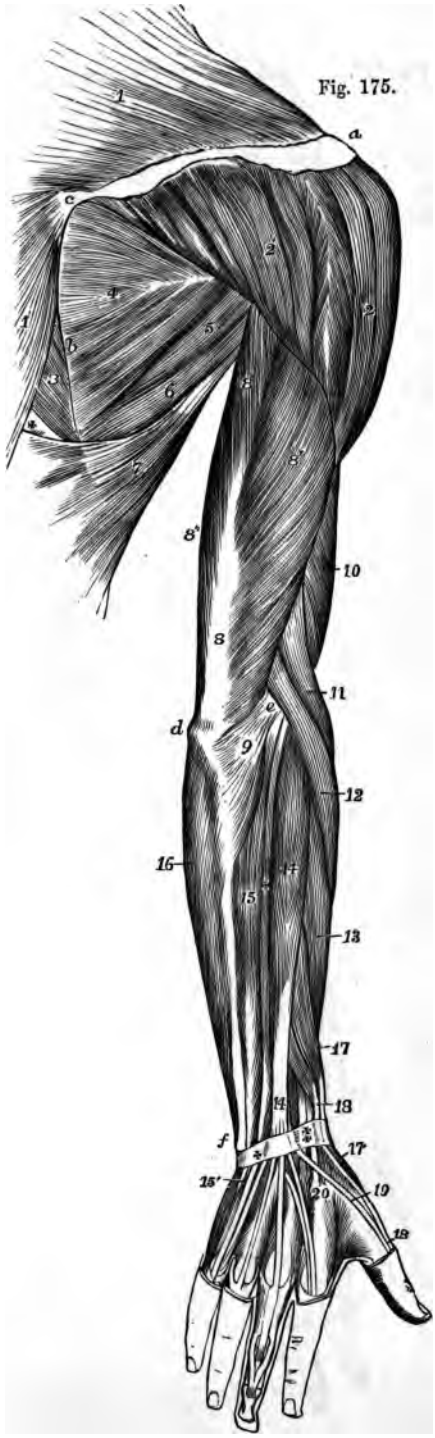


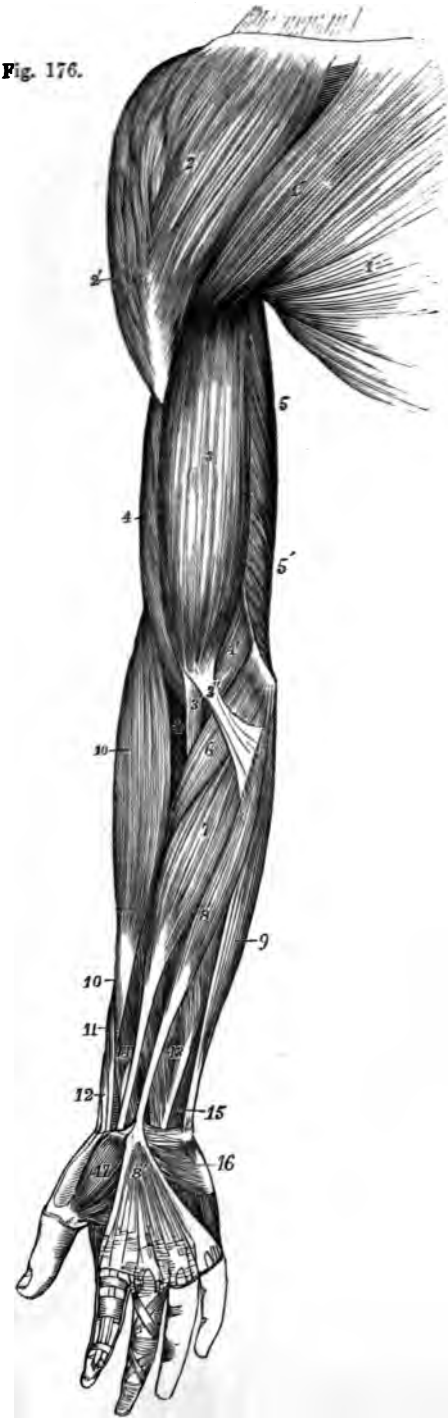
Fig. 175.—Superficial Muscles of the Shoulder and Upper Limb, seen from behind. ⅛

a, acromion; *b*, base of the scapula; *c*, tendon of the trapezius muscle over the triangular surface of the spine of the scapula; *d*, olecranon of the ulna; *e*, external condyloid eminence; *f*, lower end of the ulna; 1, trapezius; 2, acromial part of deltoid; 2′, the part of the same muscle rising from the spine of the scapula; 3, rhomboideus major; 4, infraspinatus; 5, teres minor; 6, teres major; 7, latissimus dorsi; +, triangular space between the trapezius, rhomboid and latissimus; 8, triceps extensor cubiti; 8′, its outer head; 8″, part of its inner head; 9, anconeus; 10, part of the brachialis anticus; 11, supinator longus; 12, extensor carpi radialis longior. The explanation of the remaining references will be found in the description of fig. 182.

The tendon of this muscle is incorporated with the capsule of the shoulder-joint, and between its upper margin and the coracoid process is a bursa usually communicating with that joint. Anteriorly it is in contact at its origin with the serratus magnus, and is covered at its insertion by the coraco-brachialis and biceps, while, in the interval between, it forms part of the posterior wall of the axilla.

The *supraspinatus* muscle arises from the whole surface of the supraspinous fossa of the scapula as far forward as the outer extremity of the spine, and from an aponeurosis, by which it is covered. It

Fig. 176.



completely fills the fossa, and its fibres converge beneath the acromion to a tendon, which adheres to the capsule of the shoulder-joint, and is inserted into the upper of the three facets on the great tuberosity of the humerus.

Fig. 176.—Superficial Muscles of the Shoulder and Upper Limb, from before. ½

1, pectoralis major; 1′, its clavicular portion; 2, deltoid; 3, biceps brachii; 3′, its tendon of insertion; 3″, its aponeurotic slip; 4, brachialis anticus; 4′, its inner and lower portion; 5, inner head of the triceps; 5′, lower part of the same, seen rising from behind the intermuscular septum. The explanation of the remaining references will be found in the description of fig. 179.

The *infraspinatus* muscle, occupying the greater part of the infraspinal fossa, arises from the under surface of the spine and from the whole surface of the blade of the scapula below the spine, except those parts at the lower angle and along the external border, to which the teres muscles are attached. The fibres converge to a tendon, which is concealed at first within the substance of the muscle, and is inserted into the middle facet of the great tuberosity of the humerus.

The supraspinatus muscle is covered by the trapezius and the acromion process.

The infraspinatus muscle is bound down by an aponeurosis, which superiorly and externally divides so as to enclose the deltoid muscle. It is covered by the deltoid at its upper and outer part, and by the trapezius at its upper and inner part, by

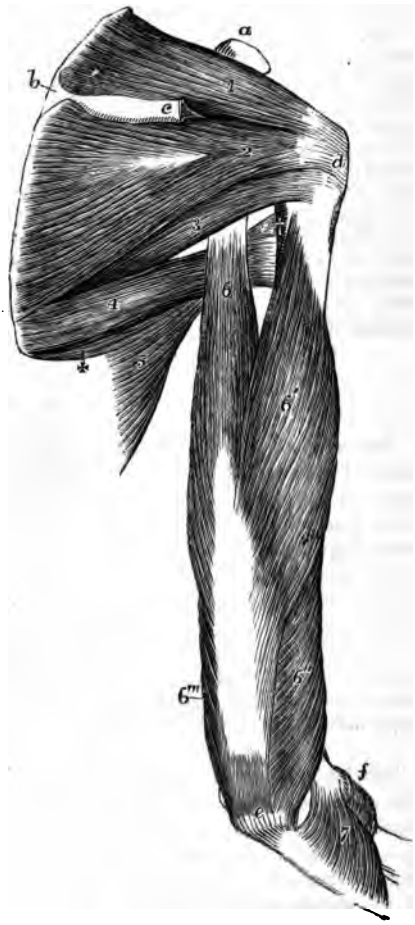
the latissimus dorsi at its lower angle, and in the intermediate portion it remains superficial.

The *teres minor* muscle, is placed along the outer border of the infraspinatus, and is intimately connected with that muscle. It arises by a series of fibres from a narrow obliquely grooved surface on the dorsum of the scapula close to the axillary border, and from aponeurotic septa between it and the infraspinatus and teres major muscles, and is inserted by tendon into the greater tuberosity of the humerus, immediately below the infraspinatus, and by fleshy fibres into the bone for a short distance lower down.

Fig. 177.—Muscles of the Right Shoulder and Arm, seen from behind. ¼

The acromion process and a part of the spine of the scapula, with the deltoid muscle, have been removed. *a*, coracoid process; *b*, triangular surface at the commencement of the spine; *c*, is close to the cut portion of the spine; *d*, greater tuberosity; *e*, olecranon of the ulna; *f*, is close to the external condyloid eminence and head of the radius; 1, supraspinatus muscle; 2, infraspinatus; 3, teres minor, placed over the triangular interval; 4, teres major; 5, part of latissimus dorsi; +, slip from the inferior angle of the scapula; †, on the edge of the humerus, points to the tendon of the latissimus dorsi and the quadrangular interval; 6, scapular head of the triceps, passing above between the teres major and minor; 6′, outer head; 6″, lower part of the same, below the spiral groove, continued from the inner head; 6‴, part of the inner head; 7, anconeus.

Fig. 177.



The *teres major* muscle arises from the flat oval surface on the dorsum of the scapula near its inferior angle, slightly from the axillary border of the bone, and from the septa interposed between it and the teres minor and infraspinatus. It is inserted by a flat tendon about two inches wide, into the inner or posterior border of the bicipital groove of the humerus, behind and in contact with the tendon of the latissimus dorsi, to which it is adherent for a short space. Close to the insertion, however, the tendons of these muscles are separated by a small bursa. The fibres of the muscle are longitudinal.

Posteriorly this muscle is covered at its lower part by the latissimus dorsi, and at its upper part it is crossed by the long head of the triceps. The outer side is surrounded by the latissimus dorsi; and the anterior surface is concealed in the upper part of its extent by the tendon of that muscle. The inner border of the muscle forms the outer margin of a triangular space, of which the other sides are the upper part of the humerus, and the axillary border of the scapula covered before and behind by the subscapular and teres minor muscles; this triangle is divided by the long head of the triceps into a superior or external quadrilateral, and an inferior or internal triangular compartment. Through the quadrilateral space pass backwards the posterior circumflex vessels and the circumflex nerve; and in the triangular subdivision the dorsal branch of the subscapular artery passes round the margin of the scapula into the infraspinous fossa. The scapular slip of the latissimus dorsi arises in connection with the teres major.

Actions.—The deltoid muscle raises the arm from the side as far as the structure of the shoulder-joint permits: that is, till it is at right angles with the trunk. Further elevation of the upper limb is effected chiefly by the trapezius; and it may be remarked, that the insertion of that muscle corresponds exactly in extent to the origin of the deltoid, so that the two muscles may be considered continuous in structure and in action. The anterior fibres of the deltoid combine with the pectoralis major to draw the humerus forwards; the posterior assist in drawing it backwards. The supraspinatus, infraspinatus and subscapularis muscles being placed more closely round the joint, when acting in concert with the deltoid probably give steadiness and precision, while the deltoid gives the main elevating force to the movement. The supraspinatus simply elevates: the infraspinatus and subscapularis carry the arm backwards or forwards when it is raised, and rotate it outwards or inwards when hanging by the side. The teres major rotates the raised humerus inwards, the teres minor outwards: acting together they assist in depressing the arm.

MUSCLES OF THE ARM.

The *coraco-brachialis* muscle, elongated in form, arises from the tip of the coracoid process of the scapula, between the pectoralis minor and the short head of the biceps, with which latter it is for a short distance conjoined. It is inserted into the inner border of the humerus near its middle, in a linear impression of from two to three inches in length, between the origin of the triceps and the brachialis anticus. From its insertion a tendinous offset is prolonged upwards to the head of the humerus.

This muscle is usually pierced by the musculo-cutaneous nerve; its outer border is in contact with the biceps muscle, and its inner with the brachial artery, by which it is crossed obliquely near its insertion. It lies in front of the tendons of the subscapularis, latissimus dorsi and teres major, and is covered by the deltoid and pectoralis major muscles.

The *biceps flexor cubiti* muscle has two heads of origin of unequal length: one of these, the internal or short head, arises conjointly with the coraco-brachialis from the coracoid process of the scapula by a tendon which is soon continued into muscle; the other, the long head, arises by a cylindrical tendon from the upper border of the glenoid ligament, within the capsule of the shoulder-joint, and this tendon passing over the head of the humerus leaves the joint by the bicipital groove, and gradually enlarges into the fleshy head as it descends. The muscular fibres from those two heads, lying side by side, unite to form an elongated and thick belly, occupying the middle and lower part of the arm: the muscle then suddenly becoming narrower a little above the bend of the elbow, is continued into the flat rounded

tendon of insertion. This tendon, slightly twisted upon itself as it descends, is inserted into the rough posterior margin of the tuberosity of the radius, and glides on the anterior smooth surface of that process by the intervention of a synovial bursa. From the front of the lower part of the muscle, and from the tendon at its inner side, there proceeds a fibrous expansion of an aponeurotic nature, which passing downwards and inwards becomes blended with the fascia of the forearm over the pronator radii teres.

Fig. 178.—Deep View of the Muscles of the Right Shoulder and Arm, from before. ½

Fig. 178.

The clavicle is divided near its middle; the pectoralis minor is entirely removed, and portions of the biceps, pectoralis major, deltoid, and latissimus dorsi, are left near their attachments. *a*, acromion; *b*, cut part of the clavicle; *c*, coracoid process; *d*, upper, and *e*, lower triangular space left at the upper and lower angles of the scapula on its anterior surface when the serratus magnus is removed; *f*, great tuberosity of the humerus; *g*, surface of the humerus below the bicipital groove, near the ridge of attachment of the pectoralis major and deltoid muscles; *h*, outer, and *i*, inner condyloid eminence of the humerus; 1, cut coracoid head, and 1′, cut glenoid tendon, of the biceps muscle; 2, folded tendon of insertion of the pectoralis major, of which one portion is seen running up to the bicipital groove; 3, lower cut end of the deltoid; 4, coraco-brachialis muscle; 5, subscapularis; 5′, its insertion into the lesser tuberosity; 6, teres major; 6′, its insertion behind and below the latissimus dorsi; 7, part of the latissimus dorsi; +, slip proceeding from the inferior angle of the scapula; 7′, insertion of the tendon after winding round the teres major in front of and higher than that muscle; 8, 8′, brachialis anticus; 9, long or scapular head of the triceps, at the upper part seen between the teres major and subscapularis muscles, the teres minor not represented; 9′, inner humeral head of the triceps; 10, flexor communis digitorum profundus, taking origin round the insertion of brachialis anticus; 11, tendon of insertion of the biceps.

Concealed above by the deltoid and pectoralis major muscles, the biceps forms in the rest of its extent the prominence of the front of the arm. It rests in its upper half on the humerus, and in its lower on the brachialis anticus, and by its inner margin is in contact in its upper half with the coraco-brachialis, in its lower with the

brachial artery. Its inferior tendon is in contact with the supinator brevis, and the fibrous expansion is stretched across the brachial artery and median nerve.

Occasionally a third head, arising from the humerus in more or less close connection with the brachialis anticus and the insertion of the coraco-brachialis, is added to the biceps muscle: this head lies generally on the outer side of the brachial artery, and has sometimes been found covering it. A muscular band has also been observed extending downwards from the biceps to the intermuscular septum over the inner condyle of the humerus, and passing over the brachial artery. (R. Quain, "The Anatomy of the Arteries," &c., p. 270, pl. 57.)

The *brachialis anticus* muscle (brachiæus internus) arises from the lower half of the anterior surface of the humerus. At the upper part of its origin it embraces the insertion of the deltoid by two angular fleshy processes; it extends downwards to the capsule of the elbow-joint, and inwards to the internal supracondyloid ridge and intermuscular septum in its whole extent; on its outer side it is separated from the external ridge and septum in the greater part of its length by the supinator longus, and only arises from it for a short distance at its upper end. It is closely adherent to the ligament in front of the elbow-joint, and terminates below in a thick mass which is inserted into the rough triangular surface on the front of the coronoid process of the ulna.

This muscle projects at each side of the biceps, and supports the brachial artery and median nerve. Fibres have been found to pass inwards from it, over the brachial artery, to the internal intermuscular septum.

The *triceps extensor cubiti*, occupying the whole space behind the humerus and intermuscular septa, consists superiorly of three portions or heads which are united lower down in a common mass, the tendon of which is inserted into the posterior and upper part of the olecranon, a bursa intervening between that tendon and the most prominent part of this process. The *middle* or *long head* (musculus anconeus longus) arises from the lower part of the glenoid cavity and an adjoining rough portion of the inferior border of the scapula, by a tendon which spreads over the sides of the muscular structure proceeding from it. The muscular fibres from this source descend and form the middle and superficial part of the common mass, presenting a flat vertical tendon on their surface inferiorly. The *external head* (m. anconeus brevis) takes origin by tendinous and fleshy fibres from the humerus along a line extending from the insertion of the teres minor, downwards on the outer border of the humerus as low as the musculo-spiral groove; from this line of origin its fibres, which are comparatively short, descend obliquely to be inserted into the tendon of the middle part. The lowest fibres of this head are bound down by a slight aponeurotic arch over the extremity of the musculo-spiral groove, and below their inferior margin other fibres are found arising from the external intermuscular septum and the surface of the humerus behind; but these last pass to be inserted more deeply than into the tendon of the middle part of the muscle, and are rather to be considered as belonging to the muscular mass which forms the internal head. The *internal* or *deep head* (m. anconeus internus), the shortest of the three, commences in a narrow pointed part behind and below the tendon of insertion of the teres major, and arises from the whole posterior surface of the humerus below the musculo-spiral groove, from the internal intermuscular septum in all its length, and from the inferior portion of the external septum; some of its lower

fibres are inserted immediately into the olecranon, and the greater part of them join the deep surface of the common tendon. No muscular fibres arise from the musculo-spiral groove itself.

The method of description above followed, in which all the fibres arising below the musculo-spiral groove are assigned to the internal head, originated with Theile. (Müller's "Archiv." &c. 1839, p. 420, and "Sœmmerring v. Baue," &c.) The long head of the triceps lies between the two teres muscles above, and is in contact with the capsule of the shoulder-joint. The musculo-spiral nerve, and the superior profunda artery, pass between the inner and outer heads as they lie in the musculo-spiral groove.

Sub-anconeus.—On removing the triceps from the lower part of the humerus, some muscular fibres will be found passing from that part of the bone to the capsule of the elbow-joint. These fibres, which are analogous to the sub-crureus in the lower limb, have been described as distinct from the triceps under the name sub-anconeus.

The *anconeus* muscle (anconeus quartus) although placed below the elbow and in that respect belonging to the forearm, is in its structure, function and nervous supply, so intimately connected with the triceps, that it is most appropriately associated in description with that muscle. It arises by a narrow tendon from the extremity of the outer condyloid eminence of the humerus, at the posterior aspect. From this the fibres diverge from one another, the upper being horizontal, the rest passing downwards with increasing degrees of obliquity, and are inserted into the olecranon on its radial aspect, and into the adjacent impression on the upper third of the shaft of the ulna. Its superior fibres are parallel to the lowest fibres of the internal head of the triceps, and are generally in contact with them.

Actions.—The biceps muscle raises the arm at the shoulder and flexes the elbow-joint; the long head of the triceps depresses the arm at the shoulder, and extends the elbow-joint. The short head of the biceps draws the arm inwards as well as upwards, as does also the coraco-brachialis. If the biceps be called into action when the hand is in pronation, its first effect, in virtue of its insertion into the back part of the tuberosity of the radius, is to produce supination of the forearm. The brachialis anticus is a simple flexor of the elbow; the external and internal heads of the triceps, and the anconeus muscle, are simple extensors of that joint.

MUSCLES OF THE FOREARM.

a. Anterior and Inner Regions (Flexors and Pronators).

The muscles on the front and inner part of the forearm are disposed in two sets, one being superficial, the other more deeply seated.

The *superficial layer* of muscles comprehends the pronator radii teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris and flexor digitorum sublimis. These five muscles are intimately united at their origin from the inner condyle, to which they are attached by a common tendon which gives fibres to each, and also sends septa between them.

The *pronator radii teres*, the most external of the group, arises by two distinct heads; one, large and superficial, is derived from the upper part of the inner condyloid eminence of the humerus, and from the common tendon above mentioned; also from the fascia and the intermuscular septum of the forearm. The second head, a thin fasciculus deeply placed, comes from the inner margin of the coronoid process, and joins the other at an acute angle. The fleshy belly thus formed proceeds outwards and down-

wards, and ends in a flat tendon which turns over the radius, and is inserted into a rough surface at the middle of the outer side of that bone.

Fig. 179.

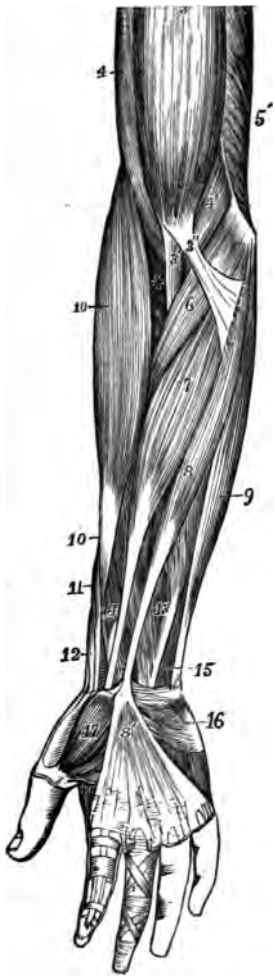


Fig. 179.—Superficial Muscles of the Forearm and Hand, seen from the front. ½

3, biceps flexor cubiti; 3′, its tendon of insertion; 3″, its aponeurotic slip; 4, brachialis anticus; 4′, its inner and lower portion; 5′, lower part of the triceps, seen rising from behind the intermuscular septum; 6, pronator radii teres; 7, flexor carpi radialis; 8, palmaris longus, passing at 8′ into the palmar aponeurosis; 9, flexor carpi ulnaris; 10, supinator longus; between 10 and 3, + marks a part of the supinator brevis; 11, extensor ossis metacarpi pollicis; 12, extensor primi internodii; 13, lower part of the flexor digitorum sublimis; 14, flexor longus pollicis; 15, small part of the flexor digitorum profundus; 16, palmaris brevis, lying on the muscles of the little finger; 17, abductor pollicis.

The pronator teres is placed superficially in the greater part of its extent; but towards its insertion it is crossed by the radial artery and nerve, and the supinator longus muscle. The ulnar border is in contact with the flexor carpi radialis and palmaris longus: the radial border forms the inner boundary of the angular space at the bend of the arm, in which are placed the brachial artery, the median nerve, and the tendon of the biceps muscle. The pronator teres covers the flexor sublimis digitorum; the ulnar artery passes behind the whole muscle, and the median nerve between its two heads.

Additional fibres frequently arise from the intermuscular septum above the inner condyloid eminence of the humerus, or from the supracondyloid process when that is present. This peculiarity is sometimes associated with a change in the direction of the brachial artery.

The *flexor carpi radialis* arises from the inner condyle by the common tendon, from the fascia of the forearm, and from the intermuscular septa placed between it and the pronator teres on one side, the palmaris longus on the other, and the flexor sublimis posteriorly. The fleshy fibres end in a flat tendon, a little below the middle of the forearm. Arrived at the carpus, the tendon occupies a special fibrous compartment situated in the outer part of the anterior annular ligament of the wrist, and runs through a groove in the os trapezium, to which it is bound by a thin fibrous sheath lined by a synovial membrane, and is inserted into the extremity of the second metacarpal bone.

A fasciculus from the inserted tendon sometimes passes to the third and even to the fourth metacarpal bone.

In the lower half of the forearm the radial artery is placed to the outer side of the tendon.

The *palmaris longus*, the smallest muscle of this group, is placed between the flexores carpi radialis and ulnaris, resting on the flexor sublimis: it arises from the inner condyle and the intermuscular septa; forming a small muscular belly, which soon ends in a long slender tendon, inserted into the palmar fascia, near the middle of the wrist, and sometimes sending a slip to the short muscles of the thumb.

The palmaris longus is frequently wanting. It is subject to many variations of form, *e. g.* the muscular fibres may occupy the middle of the muscle, which then commences and ends by an elongated tendon; or the muscular structure may be placed towards the lower end, the upper part being tendinous. Occasionally there are two long palmar muscles, one having the ordinary shape, while the other has one of the forms above referred to. The most remarkable peculiarity is that in which a small muscle, a second palmaris longus, placed nearer to the inner border of the forearm than the usual muscle, covers the ulnar artery for some space above the carpus, and terminates partly in the annular ligament or in the fascia, and partly in the short muscles of the little finger.

The *flexor carpi ulnaris*, the innermost muscle of the superficial group, arises by two heads, one of which is attached tendinously to the inner condyloid eminence of the humerus, the other to the inner side of the olecranon, and to the posterior border of the ulna for three-fourths of its length, by an aponeurosis which is inseparably connected with the investing aponeurosis of the limb. The fibres from the humeral head descend vertically, those from the ulna pass obliquely forwards, and terminate in a tendon, which, emerging from the first head, descends along the anterior margin of the muscle, and is ultimately inserted into the pisiform bone: this tendon is prolonged, by means of ligamentous structures, to the fifth metacarpal and unciform bones, as well as to the annular ligament and muscles of the little finger.

This muscle rests on the flexor profundus digitorum. The ulnar nerve passes down into the forearm, in the interval between the two heads, and is then covered by the muscle: for the middle part of its course the ulnar artery is also covered by it, and in the lower part of the forearm, the nerve and artery, emerging from behind the muscle, lie on its radial side.

The *flexor digitorum sublimis vel perforatus*, the superficial flexor of the fingers, is a broad flat muscle placed behind the preceding muscles, along with which it takes its principal origin. It is divided inferiorly into four tendons, which pass to be inserted into the second phalanx of each of the four inner digits. More particularly, it arises from the inner condyle by the common tendon, and the fibrous septa common to it and the other muscles; from the internal lateral ligament; from the anterior surface of the coronoid process at the inner side; and by a thin flat portion from the oblique line and part of the anterior border of the radius. The fleshy belly enlarges towards the middle of the forearm, and again diminishes somewhat before its division. The four tendons pass under the annular ligament of the wrist in pairs, one in front of the other; the anterior pair consisting of those for the middle and ring fingers, the posterior of those for the index and little fingers. That for the little finger is smaller than the others.

In the palm of the hand the tendons diverge, and each accompanied by a tendon of the flexor profundus, enters a fibrous sheath which binds both tendons down to the palmar surface of the phalanges. Opposite the first phalanx the tendon of the flexor sublimis divides into two parts, which fold

closely round the tendon of the deep flexor, and are reunited by their margins behind it: the two portions of the tendon thereafter separating, pass to be inserted one on each side into a ridge at the middle of the lateral border of the second phalanx. A large *synovial bursa* loosely invests the tendons of both the superficial and deep flexors of the fingers behind the annular ligament, extending downwards into the palm of the hand. In the little finger it approaches the synovial lining of the sheath, and in the thumb it usually communicates with it.

Fig. 180.

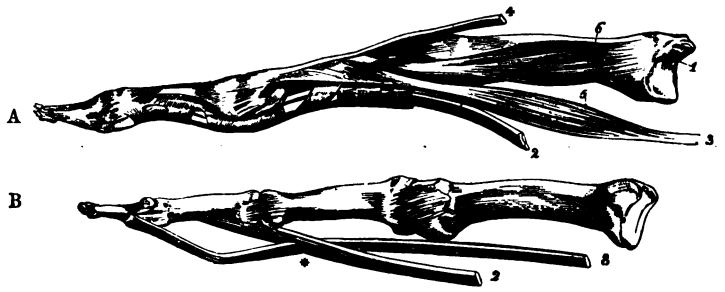


Fig. 180.—METACARPAL AND PHALANGEAL BONES OF TWO FINGERS, WITH THE TENDONS AND THEIR ACCESSORY STRUCTURES. ½

In A, the tendons of the flexor muscles are bound to the finger by the fibrous bands or retinacula. In B, these bands have been removed, as well as the synovial capsules and vincula accessoria: 1, metacarpal bone; 2, tendon of the flexor sublimis; 3, tendon of the flexor profundus; *, perforation of the sublimis by the profundus tendon; 4, tendon of the extensor digitorum communis; 5, one of the lumbricales muscles; 6, one of the interosseous muscles.

The *sheaths of the flexor tendons*, by which they are bound down to the fingers, are formed opposite the first and second phalanges by strong tendinous bands of transverse fibres (ligamenta vaginalia) attached to the rough margins of the palmar surfaces of the phalanges. Opposite the joints, flexion is secured by the substitution for those bands of a thin membrane, strengthened by oblique decussating fibres. The tendinous sheath has a synovial lining, which is simple in front, but posteriorly dips between the tendons. A few slender and loose bands (vincula accessoria tendinum, vincula vasculosa) extend from the floor of the sheath to the deep surface of both tendons. Behind each tendon, near its insertion, is a short membranous structure (ligamentum breve), which fixes the tendon to the front of the phalanx situated above that into which it is inserted.

Superiorly, the flexor sublimis is concealed by the other muscles of the superficial set, and is crossed near the radius by the radial artery; it rests on the flexor pollicis longus and flexor profundus, separated from the latter by the median nerve and the ulnar artery. In the palm of the hand, its tendons are covered by the palmar fascia, the superficial palmar arterial arch, and the branches of the median nerve; and they lie in front of the accompanying tendons of the flexor profundus.

A muscular slip is frequently given from this muscle to the flexor profundus, or to the flexor longus pollicis. The tendon for the little finger is sometimes wanting.

The *deep-seated* muscles, on the anterior surface of the forearm, are the flexor profundus, flexor pollicis longus and pronator quadratus.

The *flexor profundus digitorum*, or *flexor perforans*, a large and thick muscle, arises from the hollow at the inner side of the olecranon ; from the inner and anterior surfaces of the ulna for three-fourths of its length ; from the ulnar half of the interosseous ligament for the same distance ; and from the aponeurosis attaching the flexor carpi ulnaris to the ulna. It divides inferiorly into four tendons, only one of which, that for the index finger, is distinct from the others above the wrist—the rest being connected together as far as the palm. In the palm the tendons, as they diverge, give origin to the lumbricales muscles. Opposite the first phalanx, the tendon of each finger passes through the opening formed for its transmission in the tendon of the flexor sublimis, and is inserted into the base of the last phalanx.

Fig. 181.

Fig. 181.—Deep Anterior Muscles of the Forearm. ¼

The humeral muscles and the superficial muscles of the forearm and hand, together with the lumbricales, have been removed, and the place of the anterior annular ligament of the carpus is marked by two dotted lines. *a*, surface of the humerus above the coronoid fossa ; *b*, rough surface of the ulna, into which the brachialis anticus is inserted ; *c*, head of the radius covered by the orbicular ligament, and between this and *a*, the anterior ligament of the elbow-joint ; +, the internal lateral ligament ; *d*, the lower end of the radius ; *e*, that of the ulna ; *f*, the scaphoid and trapezium bones ; *g*, the pisiform bone ; 1, supinator radii brevis ; 2, flexor longus pollicis ; 3, flexor digitorum profundus ; 3′, its four tendons, where they are about to pass into the hand under the annular ligament ; 4, pronator quadratus on the lower part of the radius ; 5, deep head of flexor brevis pollicis ; 6, adductor pollicis ; 7, first dorsal interosseous muscle ; 8, in the second space, is placed between the first palmar and the second dorsal interosseous muscles ; in the third space, between the third dorsal and the second palmar ; in the fourth space, between the fourth dorsal and the third palmar. (For the lumbricales muscles, see Figs. 180 and 186.)

The upper extremity of this muscle embraces the insertion of the brachialis anticus. On its surface lie the median nerve and the ulnar artery and nerve. The external border is parallel with the flexor longus pollicis, from which it is separated, on the interosseous membrane, by the anterior interosseous vessels and nerve. The tendons are covered by the synovial sacs, which have been mentioned in connection with the flexor sublimis.

The *lumbricales* are four tapering fleshy fasciculi, passing from the tendons of the flexor profundus to the first digital phalanges. They arise by fleshy fibres from the outer or radial borders of the deep flexor tendons, and proceed forwards to the radial sides of the fingers, where each is inserted into an expansion of the extensor tendon on the dorsal aspect

of the metacarpal phalanx of the finger. The two inner lumbricales muscles take origin likewise from the ulnar margins of the second and third tendons.

The number of these muscles is not unfrequently diminished to three, and in rare instances is increased to five or six. The destination of one or two of them is often changed, and one finger (most frequently the third or fourth) has sometimes two inserted into it. Lastly, one muscle may be inserted into two fingers.

The *flexor longus pollicis*, placed side by side with the flexor profundus, arises from the grooved surface, on the fore part of the radius from the oblique line to the edge of the pronator quadratus; it arises also from the adjacent part of the interosseous ligament, and by a rounded fleshy and tendinous slip distinct from the rest of the muscle, from the inner part of the coronoid process. The muscle ends in a tendon which passes behind the annular ligament of the wrist close to the trapezium, turns outwards between the two heads of the flexor brevis and between the sesamoid bones, and entering a canal similar to those of the other flexor tendons, is finally inserted into the base of the second phalanx of the thumb.

Inferiorly, a part of this muscle is placed superficially between the flexor carpi radialis and the supinator longus, where it supports the radial vessels.

The *pronator quadratus*, placed close to the bones behind the last two muscles, arises from the anterior and inner surfaces of the ulna for about two inches above its carpal extremity; its fibres cross the lower part of the forearm, some transversely and others obliquely, and they are inserted for an equal distance into the fore part of the radius.

b. Posterior and Outer Regions (Extensors and Supinators).

The muscles of this group are, like those of the front of the forearm, divided into a superficial and a deep layer.

The *superficial muscles* are six in number, viz., the supinator longus, the extensores carpi radiales longior and brevior, the extensor communis digitorum, extensor minimi digiti, and extensor carpi ulnaris.

The *supinator radii longus* arises from the upper two-thirds of the external condyloid ridge of the humerus, and is interposed between the brachialis anticus and the external intermuscular septum, to which its fibres are attached. The thin fleshy mass proceeding from this elongated origin descends upon the anterior and outer border of the forearm, and ends about the middle in a flat tendon, which is inserted into the external border of the radius, near the base of the styloid process.

This muscle is covered only by skin and fascia, except at its insertion, where two of the extensor tendons of the thumb lie superficial to it.

The *extensor carpi radialis longior*, partly covered by the supinator longus, arises from the lower part of the external condyloid ridge of the humerus, and from the intermuscular septum. Its muscular belly ends at the meeting of the upper and middle thirds of the forearm in a flat tendon, which passes conjointly with that of the following muscle over the lower end of the radius in the outermost of the two broad grooves on the posterior surface of that bone, and is inserted into the base of the second metacarpal bone. A small bursa lies beneath the tendon at its insertion.

The *extensor carpi radialis brevior* arises from the outer condyloid eminence of the humerus by a tendon common to it and the other extensor muscles, from the intervening fibrous septa, from a superficial tendinous expansion, and from the external lateral ligament of the elbow-joint. Its muscular belly ends in a flat tendon, which descends with that of the extensor longior, passes through the same groove of the radius with it, and is inserted into the base of the metacarpal bone of the middle finger. A bursa is placed between this muscle and the supinator brevis, and a smaller one between the tendon and the metacarpal bone.

Fig. 182.

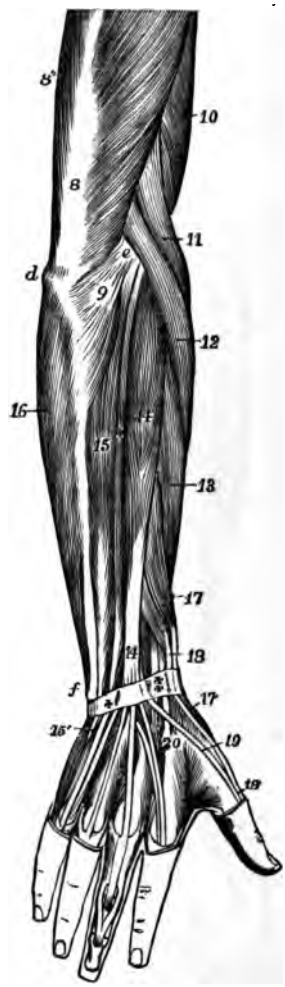


Fig. 182.—Superficial Muscles of the Forearm and Hand, seen from behind. $\frac{1}{5}$

d, olecranon; *e*, external condyloid eminence; *f*, lower end of the ulna; 8, main tendon of the triceps extensor cubiti; 8″, its inner head; 9, anconeus; 10, part of brachialis anticus; 11, supinator longus; 12, extensor carpi radialis longior; 13, —— brevior; 14, extensor communis digitorum; 15, extensor carpi ulnaris; +, between 14 and 15, extensor minimi digiti; 16, origin of the flexor carpi ulnaris by an aponeurosis from the back of the ulna; 17, extensor ossis metacarpi pollicis; 17′, its insertion into the first metacarpal bone; 18, extensor primi internodii pollicis; 18′, its insertion into the first phalanx; + and ‡, posterior annular ligament of the carpus or retinaculum of the extensor tendons; at ‡, the tendons of the long and short radial extensors; at +, the tendon of the extensor minimi digiti; 19, tendon of the extensor secundi internodii; 20, is placed on the proximal end of the second metacarpal bone, close to the insertion of the radial extensors of the carpus: in the hand, the dorsal interossei muscles are shown, and on the middle finger the insertion of the extensor tendons.

This muscle is covered by the supinator longus and extensor carpi radialis longior, and conceals the supinator brevis and the insertion of the pronator radii teres. The tendon of this muscle and that of the extensor carpi radialis longior are crossed obliquely by the extensors of the metacarpal bone and first phalanx of the thumb.

The *extensor communis digitorum*, placed between the extensor carpi radialis brevior and the extensor minimi digiti, arises by a tendon common to it and the other superficial extensor muscles, also from the fascia of the forearm, and the septa between it and the adjoining muscles. Somewhat below the middle of the forearm the muscular part ends in four tendons, which pass between the posterior annular ligament of the wrist and the innermost broad groove on the back of the radius, and diverge as they proceed along the carpus and metacarpus to reach the fingers. Here each is increased by tendinous fibres derived from the lumbricales and interosseous muscles,

forming a fibrous expansion, which covers the back of the first and second digital phalanges, and terminates upon the third phalanx. It is attached to the second and third phalanges in the following manner:—Opposite the first bone the tendon divides into three fasciculi; the central one is much thinner than the others, and is inserted into the base of the second phalanx; the two lateral parts, continuing onwards, are joined together towards the middle or fore part of the second phalanx, and having passed beyond this, are inserted into the last phalanx. On the index and little fingers the tendons are joined before their division, by the special extensor tendons of those digits.

Fig. 183.

Fig. 183.—Deep Posterior Muscles of the Forearm. ¼

a, posterior surface of the humerus above the olecranon fossa; *b*, upper and back part of the olecranon; *c*, outer and back part of the middle of the radius; *d*, lower part of the ulna, grooved for the tendon of the extensor carpi ulnaris; *e*, base of the second metacarpal bone; 1, anconeus muscle; 2, surface of the flexor digitorum profundus, exposed by the removal of the aponeurotic tendon of the flexor; 3, carpi ulnaris; 4, extensor carpi radialis brevior, and 5, the cut tendon of the extensor carpi radialis longior, both descending to their insertion at *e*, into the second and third metacarpal bones; 6, extensor ossis metacarpi pollicis; 6′, its insertion into the first metacarpal bone; 7, extensor primi internodii pollicis; 7′, its insertion into the base of the first phalanx; 8, extensor secundi internodii pollicis; 8′, its insertion into the base of the last phalanx; 9, extensor indicis; 9′, its junction with the tendon of the common extensor, which is cut short: in the metatarsal spaces the four dorsal interossei muscles are represented, the tendons of the common extensor having been removed; and at 10, the insertion of the second and third dorsal interossei, by a triangular expansion, into the tendon of the extensor communis, as well as the mode of insertion of that tendon into the middle and last phalanges, are shown.

On the back of the hand the tendon of the ring-finger gives off two processes, one on each side, which pass obliquely downwards to join the tendons of the middle and little fingers: in consequence of this arrangement it follows that if those two fingers be flexed, the tendon to the ring-finger is held downwards, and it becomes impossible to extend that finger by the action of the muscle. The tendon of the index finger is only united to that of the middle finger by a loose, transverse, semitransparent band of fibres, and is free in its action. A synovial membrane invests the tendons of this muscle as they pass under the annular ligament.

The *extensor minimi digiti* is a slender muscle which is placed between the extensor communis digitorum and the extensor carpi ulnaris, and arises by

means of a thin tendon in common with the extensor communis. The tendon in which it ends occupies a groove between the radius and ulna, passing through a ring in the annular ligament appropriated to itself, and joins the fourth digital tendon of the common extensor.

The *extensor carpi ulnaris*, the most internal of the muscles descending on the back of the forearm, arises from the external condyloid eminence of the humerus by the common tendon and from a prolongation of that structure; from the posterior border of the ulna, below the anconeus, for about the middle third; and from the fascia of the forearm. The muscular fibres derived from these sources incline somewhat inwards, and end in a tendon, which runs through a special groove in the carpal end of the ulna and a separate sheath in the annular ligament, and is inserted into the base of the metacarpal bone of the little finger on its posterior aspect.

The *deep-seated muscles* on the back of the forearm are five in number, the supinator brevis, the three extensors of the thumb and the extensor of the index finger.

The *supinator brevis* arises from the external lateral ligament of the elbow-joint, and from the annular ligament of the radius; also from a rough depression below the sigmoid cavity of the ulna, and from the outer border of that bone for two inches. The fibres of the muscle, derived from these points of attachment, as well as from a tendinous expansion on the surface, pass obliquely round the upper part of the radius, covering it closely except at the inner side, and are inserted into that bone for rather more than a third of its length, passing down to the upper margin of the insertion of the pronator teres.

The posterior interosseous nerve passes through the fibres of this muscle.

The *extensor ossis metacarpi pollicis* (abductor longus pollicis,—Alb.) arises from an elongated depression on the radial side of the posterior surface of the ulna below the origin of the supinator brevis, from a similar extent of surface of the radius below the insertion of the same muscle, and from the interosseous membrane between. Thence descending obliquely outwards it ends in a tendon, which passes in company with the extensor primi internodii pollicis through the groove on the outer border of the lower extremity of the radius, and is inserted into the base of the metacarpal bone of the thumb.

The upper part of this muscle is concealed by the common extensor, but it becomes superficial beneath, and together with the next muscle crosses the tendons of the radial extensors of the carpus, conceals the insertion of the supinator longus, and, beneath the extremity of the radius, crosses the radial artery.

The *extensor primi internodii pollicis* (extensor minor pollicis,—Alb.) lies close to the lower border of the extensor ossis metacarpi, and is much smaller than that muscle; it arises from the interosseous ligament and the radius near the middle of the forearm; its tendon accompanies that of the extensor ossis metacarpi through the same compartment of the annular ligament, and passes on to be inserted into the proximal end of the first phalanx.

The *extensor secundi internodii pollicis* (extensor major pollicis,—Alb.), much larger than the extensor primi internodii, which it overlaps, arises immediately below that muscle from the lower half of the shaft of the ulna, and from the interosseous ligament at its lower end for about an inch. Its

fibres end in a tendon, which occupies the narrow oblique groove in the middle of the posterior surface of the carpal end of the radius, and is bound down in a separate compartment of the annular ligament; it is inserted into the base of the terminal phalanx of the thumb.

The groove which lodges the radial extensors of the carpus intervenes between those which lodge the tendon of this muscle and the tendons of the other extensors of the thumb.

A part of the tendon of the extensor ossis metacarpi is often found to terminate in the upper end of the abductor pollicis. The extensor primi internodii is not unfrequently united with the extensor of the metacarpal bone, only a slender tendinous filament reaching the first phalanx. A portion of the extensor secundi internodii has been found attached to the first phalanx.

Fig. 184.

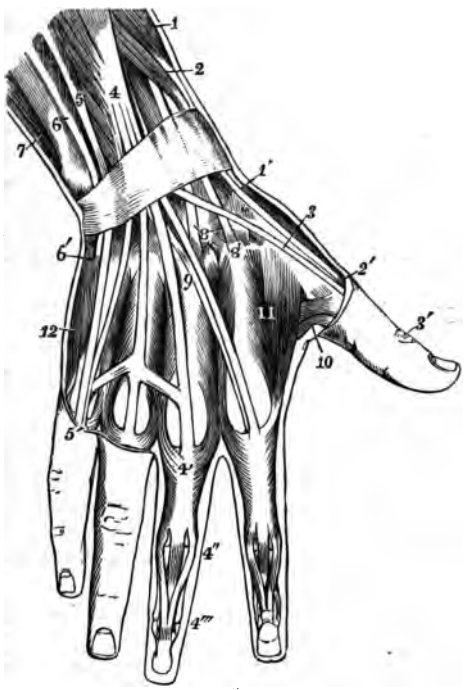


Fig. 184.—Superficial Muscles and Tendons on the Back of the Wrist and Hand (After Bourgery). ½

The posterior annular ligament of the wrist is represented. 1, lower part of the extensor ossis metacarpi pollicis; 1', its insertion; 2, extensor primi internodii pollicis; 2', its insertion; 3, 3', tendon of the extensor secundi internodii pollicis; 4, lower part of the extensor communis digitorum, before passing below the posterior annular ligament; 4', slip of this tendon descending on the dorsum of the middle finger, where it receives the insertion of the second and third dorsal interossei; 4'', division of the tendon into three portions, of which the median is inserted into the second phalanx, the two lateral passing on to be inserted into the terminal phalanx; the union of the tendons of the third, fourth, and fifth fingers is shown; the slighter union which frequently exists between the tendons of the second and third fingers is not represented in the figure; 5, extensor minimi digiti; 5', its junction with the slip of the common extensor; 6, placed on the lower end of the ulna, points to the extensor carpi ulnaris; 6', insertion of this muscle into the base of the fifth metacarpal bone; 7, part of the flexor carpi ulnaris; 8, placed on the os magnum, points to the insertion of the extensor carpi radialis brevior; 8', placed on the base of the second metacarpal bone, points to the insertion of the extensor carpi radialis longior; 9, tendon of the extensor indicis, emerging from below the annular ligament, to pass towards the index finger; 10, small part of the adductor pollicis, and deep head of the flexor brevis pollicis; 11, first dorsal interosseous or abductor indicis: in the other three interosseous spaces are seen in succession from the radial side inwards the insertion of the first palmar, second dorsal, third dorsal, second palmar, fourth dorsal, and third palmar interossei muscles; 12, abductor minimi digiti.

The *extensor indicis* (indicator) arises from the posterior surface of the ulna for three or four inches below the middle. The tendon passes with

the common extensor through a compartment of the annular ligament, comes in contact with the tendon from that muscle destined for the index finger, and unites with it to form the expansion already described.

Fig. 185.

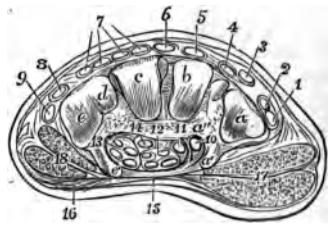


Fig. 185.—Transverse Section of the Right Hand between the Carpus and Metacarpus, showing the anterior Annular Ligament of the Carpus, and the places of the various Extensor and Flexor Tendons, seen from the distal side. ½

This figure is also designed to show the transverse arch formed by the second row of carpal bones. *a*, metacarpal articular surface of the trapezium for the metacarpal bone of the thumb; *a'*, palmar ridge of the trapezium; *b*, articular surface of the trapezoid bone for the second metacarpal bone; *c*, the surface of the os magnum for the middle metacarpal; *d*, the surface of the unciform for the fourth, and *e*, that for the fifth metacarpal bone; *e'*, unciform process; between *a'* and *e'*, the cut edge of the annular ligament is represented, the ends attached to the projecting parts of these bones, and sending another process towards the trapezium at 11, by which the tendon of the flexor carpi radialis is enclosed in the groove of the trapezium; 1, tendon of extensor ossis metacarpi pollicis; 2, extensor primi internodii; 3, extensor secundi internodii; 4, extensor indicis; 5 and 6, long and short radial extensors of the carpus; 7, the four divisions of the tendon of the common extensor of the fingers, the middle two belong to the third and fourth fingers; 8, extensor minimi digiti; 9, extensor carpi ulnaris; 10, flexor carpi radialis; 11, flexor longus pollicis; 12, marks a point between the four divisions of the flexor superficialis digitorum; 13, the same of the flexor profundus; 14, the median nerve; 15, points to the middle of the cut margin of the palmar aponeurosis stretched across the annular ligament; 16, the fibres of the palmaris brevis muscle; 17, cut surface of the muscles of the ball of the thumb; 18, muscles of the little finger.

MUSCLES OF THE HAND.

Besides the tendons of the long muscles and the lumbricales already described, there are placed in the hand one superficial muscle called palmaris brevis, the short muscles of the thumb and little finger, and the interossei muscles.

The *palmaris brevis* is a thin flat subcutaneous muscle, which arises from the inner margin of the palmar fascia and annular ligament; its fibres proceed transversely inwards, and are inserted into the skin along the inner border of the palm.

The palmaris brevis crosses the muscles of the little finger and covers the ulnar artery and nerve. It is subject to considerable variation in its breadth and thickness, consisting sometimes of only a few scattered fibres.

Muscles of the Thumb.—The fleshy mass which forms the *thenar prominence*, or ball of the thumb, consists of four muscles.

The *abductor pollicis* (abductor brevis pollicis,—Alb.), superficial and flat, arises from the annular ligament and from the ridge of the os trapezium, and, proceeding outwards and forwards, is inserted by a tendon into the radial border of the first phalanx of the thumb at its base.

The *opponens pollicis*, placed behind the abductor, arises from the annular ligament and from the os trapezium and its ridge, and is inserted into the whole length of the metacarpal bone of the thumb at the radial border.

The *flexor brevis pollicis* arises by two heads, a superficial and a deep. The superficial head is attached to the outer two-thirds of the annular ligament and to the os magnum: the deep head is attached to the os trapezoides and os magnum, to the sheath of the flexor carpi radialis and to the bases of the second and third metacarpal bones. From the superficial and deep heads of origin two strong masses of fibres which, becoming tendinous, are attached to the outer and inner sesamoid bones respectively, and are inserted into the sides of the base of the first phalanx of the thumb; the outer head is also joined by a considerable fasciculus from the deeper origin; the inner head is inserted conjointly with the adductor pollicis. The two tendons of insertion, with the sesamoid bones, play over the grooved surfaces of the first metacarpal bone. The tendon of the long flexor lies between the heads of origin, and grooves the surface of the muscle as it passes between the tendons of insertion.

Fig. 186.

Fig. 186.—Muscles and Tendons of the palmar aspect of the Hand. ½

A portion of the tendons of the superficial flexor has been cut away to show those of the deep flexor and the lumbricales. 1, tendon of the flexor carpi radialis, cut short near the place where it enters the canal in the outer attachment of the annular ligament of the carpus; 2, tendon of the flexor carpi ulnaris, inserted into the pisiform bone; 3, anterior annular ligament of the carpus; 4, abductor pollicis; 5, opponens pollicis; 6, 6, flexor brevis; 7, adductor pollicis; 8, abductor minimi digiti; 9, flexor brevis minimi digiti; 10, lumbricales, passing to their insertion on the radial side of the four fingers.

Fig. 187.

Fig. 187.—Deep Muscles of the Palm of the Hand. ½

The abductor pollicis and abductor minimi digiti, together with the anterior annular ligament and the long flexor tendons in the palm, have been removed; in the forefinger the tendons of both the superficial and deep flexors remain; in the other fingers the tendons of the superficial flexor have been removed. 1, pronator quadratus muscle; 2, opponens pollicis; 3, flexor brevis pollicis; 4, adductor pollicis; 5, opponens minimi digiti; 6, unciform bone; 7, 8, interosseous muscles.

The *adductor pollicis* arises from the anterior two-thirds of the palmar surface of the metacarpal bone of the middle finger, and is inserted into the

base of the first phalanx of the thumb along with the inner tendon of the short flexor.

MUSCLES OF THE LITTLE FINGER.—The fleshy mass at the inner border of the hand (*hypothenar prominence*) consists of three muscles passing to the little finger.

The *abductor minimi digiti* arises by tendinous fibres from the pisiform bone and the inserted tendon of the flexor carpi ulnaris, and is inserted into the base of the first phalanx of the little finger on the ulnar border.

The *flexor brevis minimi digiti*, separated at its origin from the abductor muscle by a small interval through which pass the deep palmar branch of the ulnar nerve and the communicating branch of the ulnar artery, arises from the front of the annular ligament, and from the tip of the hooked process of the unciform bone, and is inserted into the base of the first phalanx of the little finger, in connection with the preceding muscle. This muscle is sometimes absent, or becomes incorporated with the abductor.

The *opponens minimi digiti* (adductor ossis metacarpi digiti minimi,—Alb.) arises from the annular ligament and the unciform process, and is inserted into the ulnar border of the fifth metacarpal bone in all its length.

Fig. 188.

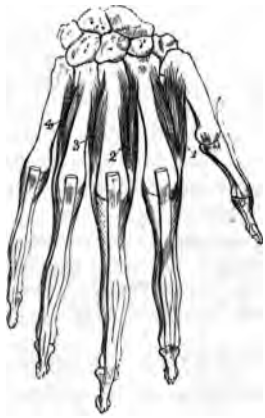


Fig. 189.

Fig. 188.—THE RIGHT HAND FROM BEHIND, SHOWING THE DORSAL INTEROSSEOUS MUSCLES. ⅔

The tendons of the extensor muscles have been removed as far as the distal ends of the metacarpal bones. 1, 2, 3, and 4, the interossei muscles, in order from the radial side inwards; their expanded insertion in connection with the extensor tendons, is shown upon the first phalanges.

Fig. 189.—THE RIGHT HAND FROM BEFORE, SHOWING THE PALMAR INTEROSSEI MUSCLES. ⅔

1, 2, and 3, refer to the first, second, and third palmar interosseous muscles.

THE INTEROSSEOUS MUSCLES occupy the intervals between the metacarpal bones. They are seven in number, all of them more or less visible from the palmar aspect, and they are divided into two sets, viz., those which are best seen on the dorsal aspect of the metacarpus, and those which are seen only in the palm. Their disposition is most easily understood by reference to their action.

The *dorsal interossei* muscles separate the fingers from the middle line of the hand; they are four in number, each occupying one of the spaces between the metacarpal bones. They are named numerically from without inwards. Each muscle arises from both the metacarpal bones between which it is placed, but most extensively from that supporting the finger upon which it acts, and the fibres converge pennately to a common tendon in the middle. Each terminates in a tendon, which is inserted partly into the base of the first phalanx, and partly into the tendon of the common extensor muscle on the dorsum of the same part of the finger. Two dorsal interossei are inserted into the middle finger and draw it to either side; of the remaining muscles one passes to the radial side of the index-finger, and the other to the ulnar side of the ring-finger; they withdraw those fingers from the middle line of the hand.

The *first* dorsal interosseous muscle or *abductor-indicis* is larger than the others; its outer and larger head of origin arises from the proximal half of the ulnar border of the first metacarpal bone, the inner is attached to the whole length of the second metacarpal bone, and between these heads there is left superiorly an interval wider than in the other dorsal interosseous muscles.

Between the heads of the abductor indicis the radial artery passes forwards to the palm of the hand; between those of the other dorsal interossei small perforating arterial branches are transmitted.

The three *palmar interossei* are adductors, drawing the index, ring, and little fingers towards the middle line of the hand. They are visible only from the palmar aspect of the hand, each one being attached to the metacarpal bone of the finger on which it acts: they terminate, like the dorsal muscles, in small tendons inserted partly into the base of the first phalanx at the side, and partly into the extensor tendon. The first palmar interosseous muscle belongs to the ulnar side of the index-finger; the others are placed on the radial sides of the ring and little fingers.

The interosseous muscles are subject to some variation in their number and form. An additional palmar interosseous muscle, going to the dorsal aponeurosis of the thumb, is described as frequent by Henle and Wood. (See J. Wood, "On some varieties in Human Myology," in the Proc. of the Roy. Soc. for 1864, p. 302.)

ACTIONS OF THE MUSCLES OF THE FOREARM AND HAND.

The muscles of the forearm may be distinguished according to their actions as pronators and supinators, flexors and extensors of the wrist, and long flexors and extensors of the fingers: those of the hand are flexors, adductors, abductors, opposers, and partially also extensors of the fingers.

Pronation is effected by the pronator quadratus and pronator teres: the flexor carpi radialis also contributes slightly to this movement. The pronator teres is fitted to flex the elbow when pronation has been completed, or when it is prevented by antagonistic muscles.

Supination is effected principally by the supinator brevis. The supinator longus is not so advantageously situated to accomplish this action; it is principally a *flexor of the elbow*, acting, however, only after that movement has been begun by the instrumentality of other muscles: in the extended and supinated condition of the forearm it assists in binding the radius more firmly to the humerus.

Flexion of the wrist is produced by the radial and ulnar flexors of the carpus, and is aided by the flexors of the fingers when the action of those muscles on the fingers is either completed, or is opposed by any resistance, as when the over-extended hand is pressed against a surface in pushing, or in the support of the body.

Extension of the wrist, in a similar manner, is accomplished not only by the three muscles specially devoted to that function, but also by the extensors of the fingers.

The flexors arising from the inner condyloid eminence of the humerus, and the

extensors arising from the outer condyloid eminence, are most advantageously situated for acting on the other joints over which they pass, when the position of the elbow joint is such as to keep them most on the stretch; but when flexion of those other joints is either completed or opposed, they have also some effect, though not great upon the elbow joint itself.

The *flexores sublimis* and *profundus* and the *lumbricales* muscles are the flexors respectively of the second, third, and first phalanges. The lumbricales, while they flex the first phalanx, at the same time, by virtue of their connection with the extensor tendons, extend the other phalanges, thus causing the fingers to pass through the movement which they undergo in making the hair-stroke in writing. They are assisted in this action by the interossei.

When the *thumb* is opposed to the other fingers, the metacarpal bone is drawn forwards, not only by the opponens muscle, but also by the abductor, and by the flexor brevis, acting when the first phalanx is flexed, or when it is fixed by the extensor primi internodii. The precise action of the abductor is to draw the thumb forwards and outwards. The extensor ossis metacarpi is entirely an abductor, as indicated by the name given to it by Albinus. The extensor primi internodii likewise is an abductor as well as an extensor of the first phalanx. The extensor secundi internodii extends both phalanges and draws the metacarpal bone directly backwards. The adductor and the inner fibres of the flexor brevis adduct the thumb. A combination of the actions of the different muscles in succession produces circumduction.

The *little finger* is withdrawn from the others by its abductor, as the ring-finger is withdrawn from the middle finger by the fourth dorsal interosseous muscle; and the abductor acting with the long flexors likewise assists the flexor brevis in keeping the first phalanx firmly down in grasping.

The *palmaris longus* has but little action, and that is exerted in tightening the palmar fascia. The *palmaris brevis* increases the hollow of the hand by pulling on the integument on the inner side, so as to increase the hypothenar prominence.

FASCIÆ OF THE UPPER LIMB.

The *superficial fascia* covering the muscles which pass from the trunk to the shoulder and upper limb, forms a complete investment of the upper part of the trunk, being continuous with that of the neck superiorly, and with those of the abdomen and hip inferiorly, and extending from the shoulder and over the arm, forearm and hand, so as to cover the whole limb. In the subcutaneous tissue of the upper limb bursæ are usually found placed over the acromion, the olecranon, and the knuckles.

The *superficial fascia of the pectoral region* encloses the mammary gland, covering it both in front and behind, and sending strong septa in between its lobes. Processes likewise extend from the investment of the gland between the masses of fat forwards to the skin and nipple, and these, from the support which they afford to the gland, have been named by Sir Astley Cooper *ligamenta suspensoria*. ("On the Anatomy of the Breast." London, 1840.)

The *superficial fascia of the arm* is most distinct opposite the bend of the elbow, where the superficial veins contained within its laminæ are numerous and large. In the palm of the hand, on the contrary, the subcutaneous tissue forms a firm connecting medium between the skin and a strong aponeurosis named the palmar fascia: it consists of a network of fibres passing between those two structures, dividing the subcutaneous fat into small granules, so as to prevent the skin from shifting to any considerable extent.

Of the *deep fascia* the following parts require special notice. The *costo-coracoid membrane* is a distinct layer of firm fascia whose strongest fibres, distinguished sometimes as the *costo-coracoid ligament*, extend from the coracoid process to the first rib at the origin of the subclavius muscle, and which conceals that muscle from view. Superiorly it is attached to the

clavicle ; inferiorly it is narrowed like a funnel, and becomes thinner as it descends upon the surface of the axillary vessels, forming the anterior part of the sheath of those vessels, while the posterior part is formed by a deep process of the cervical fascia.

The *axillary fascia* is a strong membrane stretched across the axilla, and so disposed as to maintain the skin in position across that hollow. Beneath the pectoralis major muscle is a layer of fascia attached to the chest in front of the costo-coracoid membrane : it divides into two layers to inclose the pectoralis minor, and these reuniting, it continues to pass outwards, forming a strong membrane in the angle between the pectoralis minor and short head of the biceps muscle ; lower down it is joined by the superficial investment of the pectoralis major, which is folded round the margin of that muscle, and thus strengthened, it slopes outwards and backwards to the inferior border of the scapula, where it is joined by the sheaths of the latissimus dorsi and teres major muscles. The deepest hollow of the axillary fascia is formed where the layer from the surface of the pectoralis major joins that from the pectoralis minor ; and in that part especially it is perforated by numerous lymphatics. At the angle occupied by the large vessels and nerves of the limb, it is continuous with the sheath of the vessels and with the aponeurosis of the arm. The density of this fascia offers a considerable obstacle to the progress outwards of axillary abscesses.

The *aponeurosis of the upper limb* is a strong sheath which binds together all the muscles of the arm and forearm. A strong and somewhat isolated portion, bound down to the vertebral and axillary margins and to the lower border of the spine of the scapula, covers the infraspinatus and teres minor muscles as far as they are left uncovered by the deltoid muscle. On reaching the posterior border of the deltoid muscle, this aponeurosis divides into two layers, of which the deeper is continued beneath the deltoid to the shoulder-joint, and the more superficial forms a thin aponeurosis covering of that muscle, becoming more and more slender as it passes forwards.

The aponeurosis of the arm is composed chiefly of transverse fibres, held together by others having an oblique or longitudinal direction ; it is thin over the biceps muscle, stronger where it covers the triceps, and particularly dense as it approaches the outer and inner condyloid eminences of the humerus. It is pierced on the inner side of the limb by the basilic vein, at some distance below the axilla. It is attached to the shaft and condyloid eminences of the humerus by the two processes next to be described.

The *external and internal intermuscular septa* are two fibrous partitions which bind the aponeurosis of the arm to the humerus, and with which the neighbouring muscles of the arm are intimately connected. The external intermuscular septum extends upwards from the outer condyloid eminence along the outer lateral ridge to the insertion of the deltoid, from which it receives tendinous fibres. It is pierced from behind forwards by the musculo-spiral nerve and superior profunda artery. The internal septum, much stronger, extends along the ridge from the inner condyloid eminence to the insertion of the coraco-brachialis muscle. It is traversed from before backwards by the ulnar nerve and by the inferior profunda and anastomotic arteries.

At the bend of the elbow the aponeurosis is closely connected with the periosteum covering the condyloid eminences of the humerus and the olecranon process of the ulna ; and it is strengthened by tendinous fibres sent from the triceps and biceps muscles.

The *aponeurosis* of the *forearm*, like that of the arm, is composed principally of circular fibres, strengthened, however, by longitudinal and oblique fibres

descending from the condyloid eminences of the humerus, from the olecranon, and from the superficial insertion of the biceps muscle. It is attached along the subcutaneous margin of the ulna, and may be conveniently divided into an anterior and posterior part.

The *anterior part* of the aponeurosis of the forearm is much weaker than the membrane on the posterior aspect of the limb. It is continued below into the anterior annular ligament. In the hollow immediately below the bend of the elbow, it presents a small oval aperture for the transmission of a short communicating branch between the superficial and the deep veins of the forearm. It increases in density towards the hand ; and a little above the wrist affords a sheath to the tendon of the long palmar muscle, which passes over the annular ligament to be inserted into the narrow end of the palmar fascia. Several white lines seen on the surface of the fascia mark the positions of the septa between the origins of the muscles descending from the inner condyloid eminence, which are continuous with it. Between the superficial and the deep flexor muscles, another layer of fascia is stretched from side to side ; it is stronger below than above, where it generally consists of little more than thin connective tissue.

The *anterior annular ligament* of the carpus, previously described at p. 144, is continuous at its upper margin with the fascia of the forearm, and receives some fibres from the tendon of the flexor carpi ulnaris : the lower margin is connected with a deep part of the palmar fascia, and gives origin in part to most of the short muscles of the thumb and little finger. This structure may be considered in some measure as a developed portion of the fascia of the wrist, and also as a ligament.

The *posterior portion* of the aponeurosis of the forearm, much thicker than the anterior, is intimately connected with the strong septa between the several superficial muscles, and sends off transversely a thin membrane to separate the superficial from the deeper group of muscles. Approaching the back of the wrist, the transverse fibres increase in number and strength, and these being stretched from the outer margin of the radius on one side, to the cuneiform and pisiform bones and the palmar fascia on the other, constitute the *posterior annular ligament* of the carpus (see p. 144). This structure is attached not only to the points now indicated, but is likewise connected to the several longitudinal ridges on the posterior surface of the radius, and thus converts the intermediate grooves into fibro-osseous canals to lodge the tendons of the extensor muscles. There are six separate spaces so enclosed, and each is lined by a distinct synovial sac. The outermost space corresponds with the groove on the outer side of the radius, and gives passage to the extensores ossis metacarpi and primi internodii pollicis ; the next three, placed on the back of the radius, give passage respectively to the two radial carpal extensors, the extensor secundi internodii pollicis and the common extensor of the fingers, with the extensor indicis accompanying it ; between the radius and ulna is the compartment for the extensor minimi digiti, and resting in the groove on the back of the ulna is that for the extensor carpi ulnaris.

On the *back of the hand* there is only a thin layer of fascia prolonged from the posterior annular ligament over the extensor tendons, and separating them from the superficial veins and nerves. Beneath this are special fibrous membranes stretched over the interossei muscles.

On the *palm of the hand* is the *palmar fascia*, a strong aponeurosis, consisting of a central and two lateral portions. The lateral parts are very thin ; they afford a delicate but firm covering to the muscles of the thumb

and little finger respectively. The central portion is one of the strongest fasciæ of the body. Occupying the interval between the thenar and hypothenar eminences and expanding towards the fingers, it has a somewhat triangular or fan-like form. The narrow end of the fascia, thicker than any other part, and composed of close parallel fibres, is connected by its deep surface with the anterior annular ligament, and is continuous superiorly with the tendon of the palmaris longus, when that muscle is present; the broader portion, becoming thinner and flatter as it advances towards the fingers, has a much more irregular and interlaced texture, and adheres more closely to the skin of the palm. Near the lower part of the palm it separates into four processes, each of which again subdivides into two slips next the root of a corresponding finger; and the bundles of fibres thus separated, dipping one on each side of the flexor tendons belonging to the finger, are attached to the margins of the metacarpal bone and to the transverse ligament which binds the metacarpal bones to each other. From the centre of each process longitudinal fibres are continued to the skin as far forward as the root of the finger. These digital processes of the palmar fascia are held together by irregular transverse fibres, which lie immediately under the skin, and serve to give great additional strength at the points of divergence.

MUSCLES OF THE TRUNK.

The muscles passing between the trunk and the upper limb having been already described, those which belong exclusively to the trunk itself will now be treated of under the three divisions of, 1. Dorsal muscles, extending throughout the whole length; 2. Thoracic muscles, including the diaphragm; and 3. Abdominal and Perineal muscles.

Dorsal Muscles of the Trunk (Muscles of the Back).

The muscles to be described under the above head, taken as a whole, occupy more or less deeply the hollow between the entire middle line of the vertebral spines and the prominences formed towards the sides by the mastoid processes, the transverse cervical processes, the most projecting parts of the ribs, and the crest of the ilium, and they extend from the superior curved line of the occipital bone to the lower part of the sacrum. Some consist of comparatively limited portions of muscular substance, and occupy only certain parts of the extensive region now referred to; others extend either continuously or by the serial repetition of similar fasciculi, throughout the greater part of it. These muscles, together with those in the same region which belong more properly to the upper limb, have been frequently described as constituting six successive layers; but the limits of several of these layers do not present very marked natural planes of separation, and it will be sufficient for the purpose of description to arrange those which fall properly within the present section, according to the main characteristics of their form and position, into the following groups: viz., *a*, the posterior serrati muscles; *b*, the splenius and long erectors of the spine; *c*, the complexus and transverso-spinales; *d*, the interspinales and intertransversales; *e*, the short cranio-vertebral muscles. Of these muscles those included in the first two groups may be considered as having their fibres passing outwards from the middle; those in the third group as having their fibres passing inwards; those of the fourth group as having their fibres passing in a nearly vertical direction; and those of the fifth group confined

to the upper part of the vertebral column and to the head, may be looked upon as combining some examples of the others.

SERRATI MUSCLES.—The *serratus posticus superior* is a thin flat muscle, which arises from the lower part of the ligamentum nuchæ and from the spines of the last cervical and two or three upper dorsal vertebræ by a flat tendon inclining downwards and outwards, and forming about a third of the length of the muscle; it is inserted by four fleshy digitations into the second, third, fourth, and fifth ribs, a little beyond their angles. It is directed obliquely downwards and outwards, resting on the deep muscles and the angles of the ribs. The muscle is covered, excepting at its superior border, by the rhomboid and levator anguli scapulæ muscles.

The *serratus posticus inferior*, broader and stronger than the preceding muscle, passes outwards and upwards to the four lowest ribs; it arises, by a thin aponeurotic membrane, which forms part of the posterior layer of the lumbar aponeurosis, from the spinous processes and interspinous ligaments of the two last dorsal and two or three upper lumbar vertebræ. The outer part of the muscle forms a fleshy lamella inserted by four digitations into the lower border of the last four ribs. The uppermost of those digitations is very broad, and covers in part the second; the last, varying in size with the length of the twelfth rib, is entirely concealed by the rest of the muscle. The serratus inferior is covered by the latissimus dorsi, and its aponeurotic part is firmly united for some distance with the tendon of that muscle.

Fig. 190.

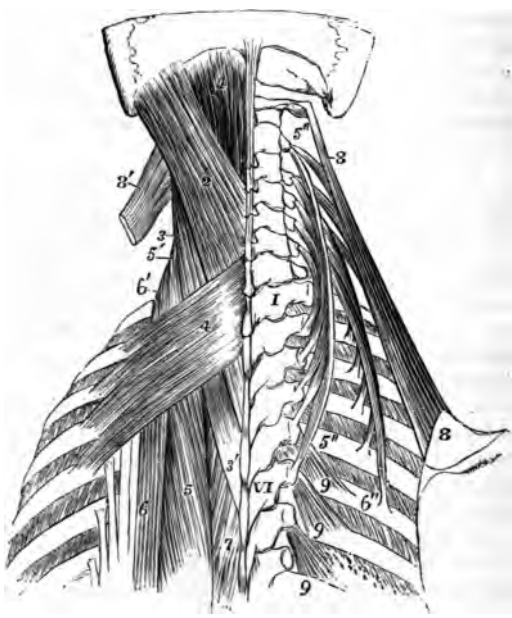


Fig. 190.—DORSAL MUSCLES OF THE UPPER PART OF THE TRUNK. ½

I, first; VI, sixth dorsal vertebra; 1, upper part of the complexus major muscle; 2, splenius capitis; 3, 3′, splenius colli; 4, serratus posticus superior; 5, upper part of the longissimus dorsi; 5′, the same continued up on the left side into the transversalis cervicis; 5″, 5″, on the right side the transversalis cervicis spread out from its attachments; 6, upper insertions of the sacro-lumbalis and accessorius; 6′ the same continued up on the left side into the ascendens cervicis; 5″, upper, 6″, lower end of the ascendens cervicis of the right side spread out from its attachments; 7, small part of the spinalis dorsi; 8, right levator anguli scapulæ, dissected out from its attachments; 8′, on the left side, the upper part of the levator scapulæ, shown in its relation to the splenius colli; 9, three of the levatores costarum shown on the right side.

Actions.—The serratus posticus superior elevates the upper ribs, and is therefore to be regarded as a muscle of inspiration. The serratus inferior acts directly as a depressor of the lower ribs, and may aid either in expiration or inspiration; in expiration by acting in concert with the muscles which depress the higher ribs; in inspiration by fixing the lower ribs and giving firmness to the origin of the diaphragm.

Splenius.—The *splenius* muscle is so named from its having the form of a strap, which binds down the parts lying under it. It is attached superiorly in part to the cervical vertebræ, in part to the skull, and is described accordingly under two names.

a. The *splenius colli* is attached inferiorly to the spinous processes of the third, fourth, fifth, and sixth dorsal vertebræ, and superiorly along with the slips of the levator anguli scapulæ to the transverse processes of the first two or three cervical vertebræ.

b. The *splenius capitis*, broader and thicker than the preceding, arises from the spines of the seventh cervical and two upper dorsal vertebræ, and from the ligamentum nuchæ as high as the third cervical vertebra. It is inserted into the lower and back part of the mastoid process, and into the outer part of the superior curved line of the occipital bone.

The splenius is covered by the trapezius, the rhomboid, and the serratus posticus superior; and on the cranium by the sterno-mastoid. It conceals, in part, the complexus and trachelo-mastoid.

Erector Spinæ.—The *erector spinæ* may either be regarded as one large composite muscle, or as consisting of seven distinct muscles. Viewed as one muscle it may be conveniently considered as formed of three columns, of which the inner, or that next the spine, is comparatively slender; the outer and inner columns of the remaining thicker mass consist each of a large lower muscle and of two successive slender continuations in an upward direction; and to all these seven portions, or muscles, distinct names have been given.

The erector spinæ takes origin inferiorly as a common mass, the outer part of which is muscular, while the inner and larger part is tendinous. The muscular portion arises from the posterior fifth of the crest of the ilium; the tendinous portion arises from the back part of the ilium, the lower and back part of the sacrum, and the sacral and lumbar spines; it is inseparably united below with the lumbar aponeurosis, and is prolonged upwards on the surface of the muscular part, concealing the multifidus spinæ. The division of the larger part into an external and internal column takes place below the level of the last rib.

a. The *ilio-costalis* (Theile) or *sacro-lumbalis*, the main muscle of the outer column, is fleshy inferiorly, springing from that part of the common origin which proceeds from the crest of the ilium; it ends in a series of tendons which incline slightly outwards, and are inserted one into each of the six or seven lowest ribs at their angles.

b. The *musculus accessorius ad ilio-costalem* (*ad sacro-lumbalem*) is a continuation of the preceding muscle. It arises by flat tendons from the upper margins of the lower six or eight ribs, internal to the tendons of the ilio-costalis, and ends superiorly by continuing the series of those tendons to the upper ribs.

c. The *cervicalis ascendens* consists of slips in serial continuation with those of the musculus accessorius, taking origin from four or five of the

highest ribs, and inserted into the transverse processes of three cervical vertebræ, usually the fourth, fifth, and sixth. Its insertions are intimately connected with those of the transversalis cervicis.

d. The *longissimus dorsi*, the main muscle of the inner column of the erector spinæ, is both larger and longer than the ilio-costalis, its original fibres passing as high as the first dorsal vertebra. Internally it is closely connected on the surface with the spinalis dorsi, from the lower part of which it generally receives one or more tendinous slips. When those slips, and the tendons of origin from the lumbar spines are cut through, the inner surface of the muscle can be brought into view. The longissimus dorsi presents two series of insertions. The inner row of insertions is a series of rounded tendons attached to the inferior tubercles of all the transverse processes of the dorsal, and the accessory processes of the lumbar vertebræ. The outer insertions form in the dorsal region a series of thin processes attached to the nine or ten lowest ribs, sometimes more or fewer, and in the lumbar region are attached by fleshy slips to the whole length of the transverse processes, and beyond these to the lumbar fascia arising from them.

e. The *transversalis cervicis* prolongs upwards the column of fibres of the longissimus dorsi. It arises from the internal tubercles of the transverse processes of the four or five highest dorsal vertebræ, and occasionally the last cervical, and is inserted into the transverse processes of five cervical vertebræ from the second to the sixth inclusive. It always receives a slip of the original fibres of the longissimus dorsi.

f. The *trachelo-mastoid* muscle, which may be regarded as the continuation of the longissimus dorsi to the head, arises in close connection with the transversalis cervicis from the upper dorsal transverse processes, and also from behind the articular processes of the three or four lowest cervical vertebræ, and forming a thin flat muscle, passes to be inserted into the posterior margin of the mastoid process, under cover of the splenius and sterno-mastoid muscles. It is the only muscle which lies between the splenius and complexus, and the only portion of the erector-spinæ concealed by the former.

g. The *spinalis dorsi* is a long narrow muscle placed at the inner side of the longissimus dorsi, and closely connected with it. It arises by numerous tendons from the spines of the first two lumbar, and the two lowest dorsal vertebræ, and is inserted into from four to eight of the higher dorsal spines. It adheres closely to the semispinalis muscle upon which it lies.

Actions.—The splenii and trachelo-mastoid muscles of both sides acting together draw backwards the head and upper cervical vertebræ: when the muscles of one side only act the extension is accompanied by lateral flexion and rotation, especially of the head on the axis.

The greater part of the erector muscles of the spine, when those of both sides are in action, bends backwards the vertebral column and trunk; and these muscles co-operate powerfully in almost every great muscular effort of the body or limbs. It is the power of these muscles to straighten the back from the bent condition, of which a measure is obtained by the muscular dynamometer; the amount of this varies in adults of medium strength from 300 lbs. to 400 lbs. By the action of the erector muscles of one side a certain amount of lateral flexion and of rotation, which is greatest in the chest, accompanies the extension. These muscles also, by their costal attachments, if the spine be fixed, depress the ribs, and thus assist in expiration; but it is likewise conceivable that the cervicalis ascendens and musculus accessorius, in acting from fixed points above, may have the effect of elevating the ribs.

Fig. 191.—View of the Deep Muscles of the Back, designed to show somewhat diagrammatically their Attachments to the Vertebral Column and Ribs. ¼

On the left side the several parts of the erector spinæ are nearly in their natural position, with the exception of the spinalis dorsi, which is drawn out laterally from the spines of the vertebræ; on the right side the spinalis dorsi has been entirely removed, the ilio-costalis drawn to the outer side so as to expose its accessory muscle, and the longissimus removed excepting small portions at its insertions. Superiorly on the left side, the trachelo-mastoid and complexus major are left nearly in their natural positions, while on the right side, the trachelo-mastoid has been entirely removed, and the complexus major, separated from its occipital attachment, has been spread out to the side so as to stretch its vertebral attachments. *a*, occipital protuberance; *b*, mastoid process; *c*, bifid spinous process of the axis vertebra; I, spinous process of the first dorsal vertebra and first rib; VI, sixth dorsal spine and transverse process and sixth rib; XII, twelfth dorsal spine and twelfth rib. On the left side of the figure, 1, complexus major muscle; 2, trachelo-mastoid; 3, serratus posticus superior, detached from the vertebral column and drawn upwards from the ribs; 4, 4, the slips of attachment of the serratus posticus inferior to the four lower ribs; 5, three slips of origin of the latissimus dorsi from the lower ribs; 5′, iliac origin of the same muscle; 6 +, common origin of the longissimus dorsi and ilio-costalis from the ilium and sacrum, &c.; 6, upper part of the longissimus dorsi; 6′,

transversalis cervicis continued up from the longissimus; 7, ilio-costalis (sacro-lumbalis), drawn slightly inwards to show the slips of insertion into the lumbar fascia and the various ribs; inside the costal insertions are seen the origins of the accessorius; 7′, the ascendens cervicis continued upwards from the accessorius; 8, spinalis dorsi. On the right side 6 marks, in the lumbar region, the insertions of the longissimus dorsi into the upper four transverse processes (the insertion into the accessory processes not being shown), in the dorsal region the narrower tendons of insertion into the lower part of the dorsal transverse processes (the six lower only are represented); 6′, the series of insertions into nine ribs; 7, the ilio-costalis drawn outwards; 7′, placed between the lowest costal insertion of the ilio-costalis and the lowest origin of the accessorius; 7″, extension of the ascendens cervicis from the fifth rib towards the neck; 9, 9, semispinalis colli; 10, 10, semispinalis dorsi; 11, 11, lower dorsal and lumbar parts of the multifidus spinæ, which appears again above the semispinalis colli, above the upper 9; 12, placed upon the eighth rib, levatores costarum, long and short; 13, in the upper part of the figure points by four lines to the rectus capitis posticus, rectus major, obliquus superior and obliquus inferior muscles.

COMPLEXUS AND TRANSVERSO-SPINALES.—The muscles of the complicated group comprising the *complexus, semispinalis, and multifidus spinæ*, present the feature in common of ascending with an inward inclination, and are thus distinguished from those last described. The most superficial, the complexus, not usually included in this group, but obviously resembling the others, has the longest and most vertical fibres, but is the shortest as a whole, being limited to the upper dorsal and the cervical region; the muscle beneath it, the semispinalis, occupies the greater part of both these regions; while the multifidus spinæ, extending from the sacrum to the axis, has the shortest and most oblique fibres.

The *complexus* (*complexus major*) arises by tendinous points from the transverse processes of the seven highest dorsal and seventh cervical vertebræ, and from the articular processes of three other cervical vertebræ, together with the capsular ligament uniting them; and it is inserted into the large internal impression between the two curved lines of the occipital bone. It is narrower above than below, and its inner margin in the neck is in contact with the ligamentum nuchæ. Above the middle the muscle is partly crossed by a tendinous intersection. One interrupting tendon in particular, on the inner side, is so constant that the fibres connected with it, viz., those ascending from the three or four lowest points of origin, are often described separately, under the name of *biventer cervicis:* this portion of the muscle is also frequently connected by a tendinous slip with one or two of the spinous processes belonging to the last cervical or first dorsal vertebra.

The complexus muscle is covered by the splenius, except at its lowest origins from the dorsal vertebræ and at the internal portion of its upper extremity; the transversalis cervicis and trachelo-mastoid rest upon its series of origins, and the semispinalis colli, the posterior recti, and the obliqui capitis, together with the deep cervical artery, are concealed by it.

The *semispinalis* muscle consists of fibres extending from transverse processes to spines, each bundle crossing over about five vertebræ. It arises from the internal tubercles of the transverse processes of numerous dorsal vertebræ, usually the ten highest, and is inserted into spines from the axis to the fourth dorsal vertebra inclusive. It is described in two parts:—

a. The *semispinalis colli* is the part under cover of the complexus. It arises from the upper five or six dorsal transverse processes, and is inserted into spines of cervical vertebræ from the second to the fifth inclusive, being thickest at its insertion into the second vertebra.

b. The *semispinalis dorsi*, not covered by the complexus, consists of small muscular bundles interposed between tendons of considerable length, and forms an elongated thin stratum, especially towards its lower border. It arises from transverse processes of dorsal vertebræ from the tenth to the fifth inclusive, and is inserted into the spines of the last two cervical and first four dorsal vertebræ.

The *multifidus spinæ* reaches from the sacrum to the axis vertebra, passing up under cover of the semispinalis, and is much more largely developed towards the lower than the upper end of the column. In the sacral region the fibres arise from the deep surface of the tendinous origin of the erector spinæ, from the groove on the back of the sacrum as low as the fourth foramen, from the inner part of the posterior extremity of the iliac crest, and from the ligaments between that bone and the sacrum; in the lumbar region they take origin from the mammillary processes; in the dorsal region from the transverse processes; and in the neck from the articular processes of the four lower cervical vertebræ. From these several points the muscular bundles ascend obliquely, to be inserted into the laminæ of the vertebræ, and into the spines from their bases nearly to their extremities. The fibres from each point of origin are fixed to several vertebræ, some being inserted into the side of the spinous process next above, and others ascending more and more vertically as high as the fourth from the place of origin; the longer fibres from one origin overlapping those from the origin next above.

The *rotatores spinæ* are eleven pairs of small muscles, which may be regarded as the deepest fibres of the multifidus spinæ in the dorsal region, and are distinguished by being more nearly horizontal than the rest. Each arises from the upper and back part of the transverse process, and is inserted into the vertebra next above, at the inferior margin and on part of the surface of the lamina, as far as the root of the spinous process.

INTER-TRANSVERSALES.—The *inter-transversales* are short muscles passing nearly vertically from vertebra to vertebra between the transverse processes. They are most developed in the cervical, and least in the dorsal region. Beneath each cervical transverse process there are two such muscles, one descending from the anterior, and another from the posterior part of the process. In the lumbar region there are likewise two sets: one set, the *inter-transversales laterales* lie between the transverse processes, and are in series with the levatores costarum; the other set, *inter-transversales mediales* or *inter-accessorii*, pass from the accessory process of one vertebra to the mammillary process of the next, and are in series with the inter-transversales of the dorsal region.

INTERSPINALES.—The *inter-spinales* are short vertical fasciculi of fleshy fibres, placed in pairs between the spinous processes of the contiguous vertebræ. They are best marked in the neck, where they are connected one to each of the two parts into which the spinous process is divided. In the dorsal part of the column only a few are met with, and these are not constant.

The *spinalis cervicis* consists of a few irregular bundles of fibres, of greater length than the preceding muscles, placed close to the ligamentum nuchæ: they arise by two or more heads from the spines of the fifth and sixth cervical and sometimes other neighbouring vertebræ, and are inserted into the spine of the axis, and occasionally into the two vertebræ next below it. This muscle is sometimes wanting. (See Henle & Heilenbeck, in "Müller's Archiv.," 1837.)

The name *sacro-coccygeus posticus*, or *extensor coccygis*, has been given to slender fibres occasionally found extending from the lower end of the sacrum to the coccyx,

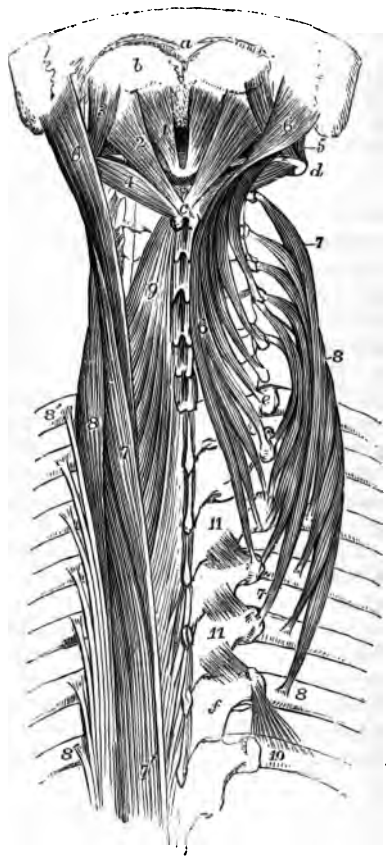
and representing the extensor of the caudal vertebræ of other animals. (Günther and Milde, "Chirurgische Muskellehre," quoted in Theile, "Sömmerring von Baue," &c.)

SHORT POSTERIOR CRANIO-VERTEBRAL MUSCLES.—The *rectus capitis posticus major* arises by a narrow tendon from the spinous process of the axis, and expanding as it passes upwards and outwards, is inserted into and beneath the outer part of the inferior curved line of the occipital bone. Its insertion is inside and below that of the superior oblique muscle.

Fig. 192. — VIEW OF THE DEEP POSTERIOR MUSCLES OF THE UPPER PART OF THE VERTEBRAL COLUMN. ½

a, posterior occipital protuberance; *b*, surface between the superior and inferior curved lines on which the complexus is inserted; *c*, spinous process of the axis vertebra; *d*, transverse process of the atlas; *e*, transverse process of the first dorsal vertebra; *f*, lamina of the sixth dorsal vertebra; 1, rectus capitis posticus minor muscle; 2, rectus posticus major; 3, obliquus superior; 4, obliquus inferior; 5, rectus capitis lateralis; 6, trachelo-mastoid, the muscle of the right side turned inwards and its slips of attachment to the dorsal and cervical transverse processes separated from each other; 7, transversalis cervicis, the figures are placed near the extreme ends of the muscle on the right side; 7′, on the left side, upper part of the longissimus dorsi continued into the transversalis cervicis; 8, ascendens cervicis, the muscle of the right side is spread out; 8′, on the left side, the seven upper tendinous insertions of the ilio-costalis and accessorius muscles; 9, upper part of the semispinalis colli of the left side; 10, placed on the seventh rib of the right side, close to the insertion of its levator costæ muscle; 11, 11, three rotatores vertebrarum between the third and seventh dorsal vertebræ.

Fig. 192.



The *rectus capitis posticus minor* arises from the posterior arch of the atlas by the side of the tubercle, and expands as it passes to be inserted into the inferior curved line of the occipital bone, and the rough surface between that and the foramen magnum.

The *obliquus capitis inferior*, the strongest of the muscles now under consideration, arises from the spinous process of the axis, between the origin of the rectus posticus major and the insertion of the semispinalis colli, and is inserted into the extremity of the transverse process of the atlas.

The *obliquus capitis superior*, smaller than the preceding muscle, arises from the upper surface of the transverse process of the atlas, inclines from

thence obliquely upwards and backwards, increasing somewhat as it ascends, and is inserted into a groove situated externally to the inferior curved line of the occipital bone.

The two oblique muscles, with the rectus major, form the sides of a small triangular space, in the area of which the posterior primary branch of the sub-occipital nerve and the vertebral artery will be found.

Actions.—The transverso-spinales muscles, including the complexus, are essentially extensors of the head and vertebral column; and the movements produced by them vary according as the muscles of one side or both are in action, in a manner similar to that already pointed out in regard to the erector muscles.

The interspinales and intertransversales muscles approximate the vertebræ between which they pass, and thus may act as extensors and lateral flexors respectively of the portion of the vertebral column in which they are situated.

Of the four muscles last described, two—the rectus minor and superior oblique—act principally by drawing the head backwards, that being the chief movement allowed between the atlas and occipital bone; while the principal action of the rectus posticus major and the inferior oblique, when acting on one side, is to rotate the atlas and skull upon the axis.

Dorsal and Lumbar Fasciæ.—Under the name of *lumbar fascia* or *aponeurosis* it has been customary to describe three layers of strong fibrous substance sheathing the erector spinæ and quadratus lumborum muscles. The deeper parts of this structure, to which by some the name of lumbar fascia is restricted, will be described along with the abdominal muscles, with which they are chiefly connected. The *superficial* or *posterior* layer is that through which the latissimus dorsi and serratus posticus inferior are attached to the spines of the dorsal, lumbar and sacral vertebræ and to the crest of the ilium. This layer, which is of considerable strength, extends outwards beyond the origin of the latissimus and serratus inferior, and being closely united with the middle layer, binds down firmly the erectores spinæ muscles: it is by some described as the lower part of the vertebral aponeurosis, with which it is continuous, by others it has been named the aponeurosis of the latissimus dorsi.

The *vertebral aponeurosis*, strictly so called, is situated on the same plane as the serratus posticus inferior, and consists of a thin lamella which separates the muscles belonging to the shoulder and arm from those which support the spine and head. Its fibres are for the most part transverse; some however are longitudinal. Above, it passes beneath the superior serratus; below, it is connected with the tendons of the latissimus and inferior serratus muscles, and in being stretched from the spinous processes outwards across the vertebral groove, it helps to enclose the angular canal in which are lodged the long extensor muscles.

Muscles of the Thorax.

The muscles of the thoracic wall are the inter-costales, levatores costarum, subcostales and triangularis sterni, and along with these the diaphragm intervening between the thorax and abdomen may conveniently be grouped.

The *intercostal muscles* consist of two thin layers of oblique short muscular fibres filling up the inter-costal spaces: these layers are named respectively the external and internal muscles.

The *external intercostal* muscles are formed of muscular fibres, with some tendinous fibres intermixed, directed obliquely downwards and forwards from one rib to another. Their extent for the most part is from the

tubercles of the ribs nearly to the outer end of the cartilages; but in the two lowest intervals they reach forwards to the ends of the spaces. Thin tendinous fibres having the same direction as the external intercostal muscles are continued forwards between the costal cartilages from the points where the muscles cease to the sternum, and there cover the internal intercostals.

Fig. 193

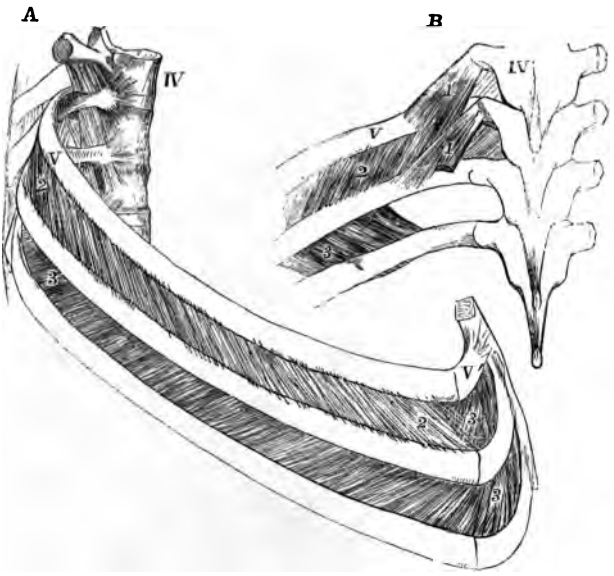


Fig. 193.—View of several of the Middle Dorsal Vertebræ and Ribs, to show the Intercostal Muscles (after Cloquet). ½

A, from the side; B, from behind.

IV, the fourth dorsal vertebra; V, V, the fifth rib and its cartilage; 1, 1, the levatores costarum muscles, short and long; 2, the external intercostal muscles in the upper of the two intercostal spaces represented; 3, the internal intercostal layer shown in the lower of the two spaces represented by the removal of the external layer, and seen in A in the upper space, where the external layer terminates in front: the deficiency of the internal layer towards the vertebral column is shown in B.

The *internal intercostal* muscles, placed deeper than the preceding, are attached to the inner margins of the ribs and their cartilages. Commencing at the anterior extremities of the cartilages of the ribs, they extend as far back as a point within the angles of those bones. The fibres incline downwards and backwards, crossing those of the external intercostals; they are, however, somewhat shorter and less oblique in their direction.

The internal are separated from the external intercostal muscles at the back of the spaces by the intercostal vessels and nerves; they are lined internally by the pleura.

The *levatores costarum*, twelve on each side, arise from the tips of the transverse processes of the seventh cervical and eleven highest dorsal vertebræ. Corresponding in direction with the external intercostal muscles, on which they lie, they pass downwards and outwards, spreading as they

descend, and each is inserted into the outer surface of the rib belonging to the vertebra below that from which it springs. The levator muscles belonging to the lower ribs present some longer additional fibres which, passing over one rib, are inserted into the next one below ; these fibres are sometimes distinguished as *levatores longiores costarum.*

The levatores costarum lie in series superiorly with the scalenus medius and posticus, and inferiorly with the external range of lumbar inter-transverse muscles.

Fig. 194.

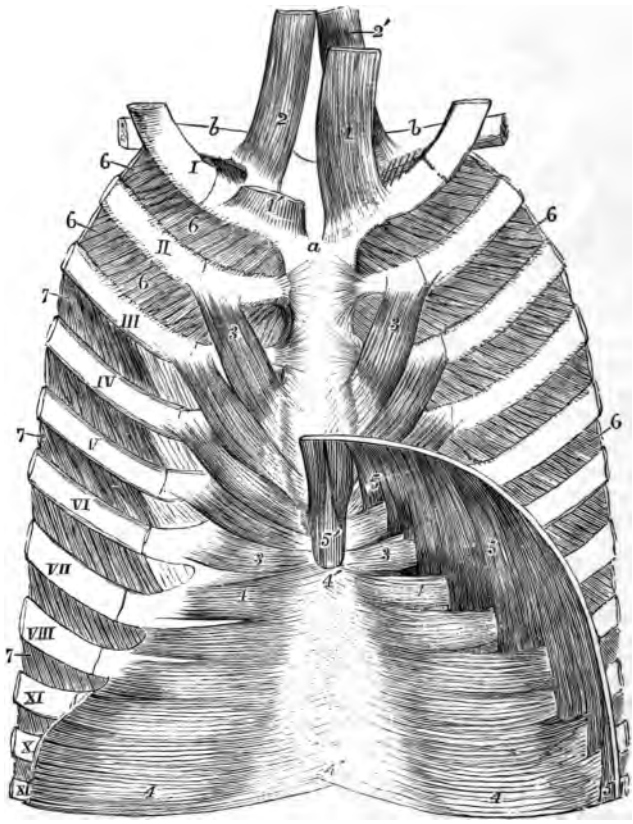


Fig. 194.—VIEW OF THE DEEP MUSCLES OF THE ANTERIOR WALL OF THE THORAX, SEEN FROM BEHIND (modified from Luschka). ¼

a, back of the manubrium of the sternum ; *b*, clavicles ; I to XI, the anterior parts of eleven ribs and costal cartilages ; 1, 1′, sterno-thyroid muscle, that of the right side being cut short to show more fully the next muscle ; 2, 2′, the sterno-hyoid ; 3, triangularis sterni ; 4, upper part of transversalis abdominis united in 4′, 4′, the back of the linea alba ; 5, attachments of the diaphragm to the lower ribs (the twelfth not represented in the figure), indigitating with those of the transversalis ; 5′, the two slips to the ensiform process ; 6, internal layer of intercostal muscles extending to the sternum, shown in all the spaces on the right side, but only in the two uppermost of the left side ; 7, in the lower spaces of the left side, indicates the external layer of intercostal muscles exposed by removing the internal layer.

The *subcostal* or *infracostal* muscles are small bundles lying on the inner aspect of the thoracic wall, close to the surface of the internal intercostals, and chiefly in the neighbourhood of the angles of the ribs. They follow the same direction as the internal intercostal muscles, but their fibres extend over two or three intercostal spaces. They are most constant on the lower ribs (see fig. 195).

The *triangularis sterni*, a thin stratum of muscular and tendinous fibres placed within the thorax, behind the costal cartilages, arises from the deep surface of the ensiform process of the lower part of the body of the sternum, and of the cartilages of one or two of the lower true ribs. Its fibres pass outwards and upwards in a diverging manner, the lowest being horizontal, the middle oblique, and the upper becoming more and more nearly vertical; and are inserted by separate slips into the cartilages of the true ribs from the sixth to the second inclusive, on the lower border and inner surface of each, at the junction with the bony part. At the lower margin the fibres are in the same plane with those of the transversalis abdominis, of which this muscle is a continuation upwards.

The triangularis sterni is subject to much variation as to its extent and points of attachment in different bodies, and even on the opposite sides of the same body. The internal mammary artery and veins pass between its anterior surface and the costal cartilages.

Occasional Muscle.—The rectus sternalis, or *sternalis brutorum*, is an elongated muscle, of nearly the same length as the sternum, frequently seen lying in front and parallel to the outer margin of that bone, and over the inner part of the pectoral muscle. It is fleshy in the middle and tendinous at both ends; it is attached superiorly to the sternum in connection with the tendon of the sterno-mastoid, and inferiorly it is connected with the rectus abdominis muscle. It is rarely present on both sides. It represents a muscle which is constant in some animals.

THE DIAPHRAGM.

The *diaphragm*, *phren*, *septum transversum*, or *midriff*, forms a musculo-tendinous partition between the abdominal and thoracic cavities. It consists of muscular fibres which arch upwards as they converge from the circumference of the visceral cavity to a tendinous structure in the centre, and it is perforated by the various structures which pass from the thorax to the abdomen.

The fibres arise from the bodies of several of the upper lumbar vertebræ by two thick crura; from two arches on each side external to the bodies of the vertebræ, called ligamenta arcuata; and from the ensiform cartilage and the cartilages of the six lower ribs.

a. The *crura* arise by tendinous fibres more or less distinctly aggregated into two bundles which are attached over a varying extent of surface. On the right side they are connected with the first, second, and third lumbar vertebræ, and the interposed fibro-cartilages, or sometimes with the second, third, and fourth; on the left side, the attachment is shorter by the breadth of one vertebra. The tendons of both crura curve forwards and upwards so as to enclose the aorta in an arch between them and the bodies of the vertebræ; their inner margins are united behind, so that they form a nearly complete fibrous ring round that vessel. The muscular fibres of the crura, springing from those tendons in thick bundles, on each side of the aorta, diverge as they pass upwards to the central aponeurosis. The innermost fibres on each side decussate with those of the side opposite, those

of the right usually lying anterior to those of the left, and, curving upwards, limit an opening for the transmission of the œsophagus, before ending in the central aponeurosis.

Fig. 195.

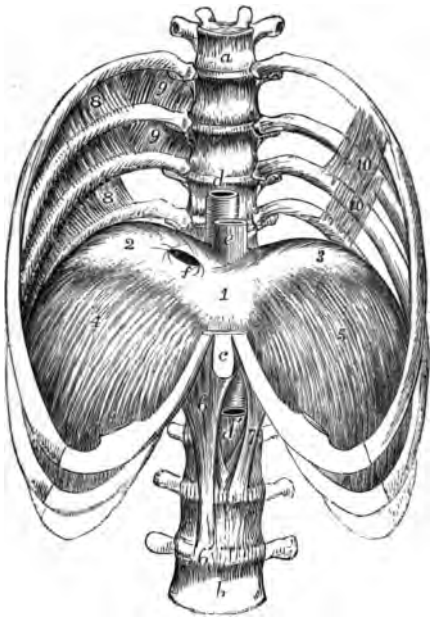


Fig. 195.—THE LOWER HALF OF THE THORAX, WITH FOUR LUMBAR VERTEBRÆ, OPENED SO AS TO SHOW THE DIAPHRAGM FROM BEFORE (modified from Luschka). ¼

a, sixth dorsal vertebra; *b*, fourth lumbar vertebra; *c*, ensiform process of the sternum; *d*, the aorta descending in front of the lower dorsal vertebræ; *d'*, the aorta emerging in the abdomen below the arch formed by the meeting of the pillars of the diaphragm; *e*, the œsophagus descending through its aperture in the diaphragm; *f*, opening in the tendon of the diaphragm for the inferior vena cava; 1, central, 2, right, and 3, left division of the trefoil tendon of the diaphragm; 4, right, and 5, left muscular part, descending from the margins of the tendon to be attached to the ribs; 6, the right, and 7, the left crus or pillar of the muscle; 8 to 8', in the three upper intercostal spaces of the right side the internal layer of intercostal muscles interrupted towards the vertebral column, where in the two upper spaces the external layer, 9, 9, is seen; in the lowest space shown the external layer is not represented; 10, 10, on the left side, indicate the form and position of a part of the subcostal or innermost layer of intercostal muscles.

b. The *ligamentum arcuatum internum* is a fibrous band which extends from the body to the transverse process of the first lumbar vertebra, and sometimes also to that of the second, and arches over the upper part of the psoas muscle. The *ligamentum arcuatum externum* extends outwards from the transverse process of the first lumbar vertebra to the last rib, arching over the front of the quadratus lumborum: it is the upper part of the fascia covering that muscle, somewhat increased in thickness. From both ligamenta arcuata diaphragmatic muscular fibres take their origin, and are directed upwards to the posterior part of the tendinous centre.

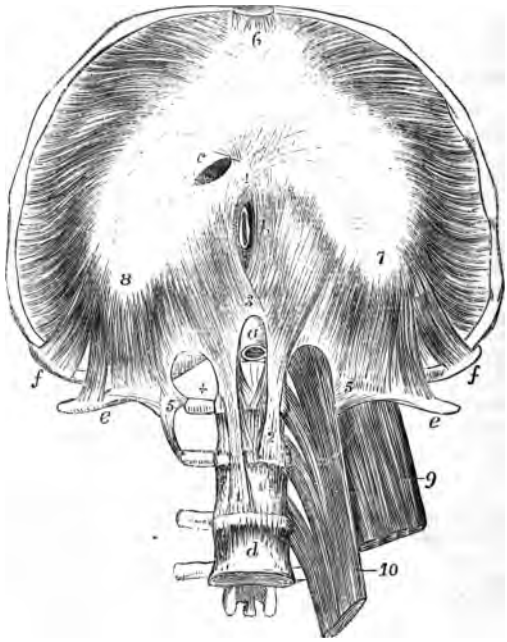
c. The fibres arising from the cartilages of the six lower ribs form a series of serrated slips interdigitating with the attachments of the transversalis abdominis muscle. They sometimes arise also in part from the osseous ribs. The fibres proceeding from the ensiform cartilage form a narrow slip, sometimes divided, on each side of which there occurs an interval, in which the lining membranes of the thorax and abdomen are separated only by a small quantity of loose connective tissue. The anterior fibres of the diaphragm are much the shortest. The fibres of the sternal and costal slips, after being united into the general plane of the muscle, rise in an

arched and converging manner to be inserted into the anterior and external margins of the central tendon.

d. The *central tendon—trefoil*, or *cordiform*, *tendon*, or *phrenic centre*, is a strong aponeurosis, forming the central and highest part of the diaphragm. It is elongated from side to side, and consists of three *lobes* or *alæ*, partly separated by indentations. The right lobe is the largest; and the left, which is elongated and narrow, is the smallest of the three. The central tendon is surrounded on every side by the muscular portion of the diaphragm, the fibres of which are directly continuous with those of the tendon. The tendinous fibres cross one another, and are interwoven in various directions.

Fig. 196.—View of the Diaphragm, from below. $\frac{1}{3}$

Fig. 196.



In the preparation from which this figure is drawn, the lower ribs and sternum are thrown upwards so as to expose and stretch the lower surface of the diaphragm, and the four upper lumbar vertebræ have been exposed by the removal of all the muscles on the right side, and the dissection of the psoas magnus and quadratus lumborum on the left side. *a*, the aorta emerging in the abdomen below the tendinous arch formed by the union of the pillars of the diaphragm on the first lumbar vertebra; *b*, the œsophagus seen entering the abdomen through the aperture in the united muscular crura (this aperture should have been represented a little to the left of the middle line); *c*, the aperture for the vena cava inferior situated at the place of union of the middle and right divisions of the trefoil tendon; *d*, the body of the fourth lumbar vertebra; *e*, *e*, the twelfth ribs near their extremities; *f*, *f*, the ends of the eleventh ribs; 1, the tendinous part of the right crus; 2, the left; 3, the tendinous arch formed by their union over the aorta, above which the decussation of muscular fibres is seen; 4, second decussation of muscular fibres in front of the œsophageal opening; 5, on the right side, placed near the end of the transverse process of the first lumbar vertebra, towards which, arching from above and from within, over the +, is seen the ligamentum arcuatum internum; and from which, passing towards *e*, is seen the ligamentum arcuatum externum; 5′, on the left side, is in a similar position, but here the quadratus lumborum muscle is seen descending from the twelfth rib behind the ligamentum arcuatum externum, and the upper part of the psoas muscle is within the ligamentum arcuatum internum; 6, the middle division of the trefoil tendon, from which in front pass the slips of attachment of the diaphragm to the ensiform process; 7, the left, and 8, the right divisions of the trefoil tendon; from the outer and anterior margins of these the costal slips of the muscle are seen diverging, and from the posterior border of the tendon the slips of origin proceeding from the ligamenta arcuata and the tendinous arch of the crura; 9, part of the quadratus lumborum; 10, part of the psoas magnus.

Foramina.—There are in the diaphragm three large perforations for the passage respectively of the aorta, the œsophagus, and the vena cava, besides some smaller holes or fissures which are less regular.—*a.* The foramen for the aorta (hiatus aorticus), placed in front of the vertebræ, is bounded by tendinous fibres of the crura as already described. Besides the aorta, this opening transmits the thoracic duct, and generally also the vena azygos.—*b.* The foramen for the œsophagus, higher and farther forward than the preceding, as well as a little to its left, is separated from that opening by the decussating fibres of the crura. It is oval in form, and is generally entirely surrounded by muscular fibres; in some rare cases, however, a small part, the anterior margin, is found to be tendinous, being formed by the margin of the central tendon.—*c.* The opening for the vena cava (foramen quadratum) is placed in the highest part of the diaphragm, in the tendinous centre at the junction of the right and middle alæ, posteriorly. Its form is somewhat quadrangular; and it is bounded by fasciculi of tendinous fibres running parallel with its sides.

Besides the foregoing large foramina, there are small perforations through the crura for the sympathetic and splanchnic nerves on both sides, and for the vena azygos minor on the left side. Moreover, the larger azygos vein often takes its course through the right crus.

The upper or thoracic surface of the diaphragm is highly arched. Its posterior and lateral fibres, ascending from their connection with the lower margin of the thorax, are for a considerable extent placed close to the ribs, the lungs not descending so far as their attachments. The vault of the diaphragm rises higher on the right than on the left side. On the right side in the dead body it rises to the level of the fifth rib at the sternum, and on the left side only as high as the sixth. This difference has relation to the great size and firmness of the liver on the right side. It is covered superiorly by the pleura and the pericardium; the fibrous layer of the latter membrane blending with the tendinous centre, as well as with the fascia covering its muscular substance. The lower surface, of a deeply concave form, is lined by the peritoneum, and has in apposition with it the liver, the stomach, the pancreas and spleen, and the kidneys.

Actions.—Movements of Respiration.—The mechanical act of respiration consists of two sets of movements, viz., those of inspiration and of expiration, in which air is successively drawn into the lungs and expelled from them by the alternate increase and diminution of the thoracic cavity. The changes in the capacity of the thorax are effected by the expansion and contraction of its lateral walls, called *costal respiration*, and by the depression and elevation of the floor of the cavity, through contraction and relaxation of the diaphragm, called *abdominal respiration*. These two methods of respiration are normally combined, but in different circumstances one method is resorted to more than another. Thus, abdominal respiration is most employed in the male, costal respiration most in the female.

Inspiration.—The study of the movements of the thoracic walls in respiration presents the difficulty that those movements cannot be perfectly imitated on the prepared skeleton, because the force cannot on it be applied between one rib and another as during life, and because the resistance to expansion is no longer of the same description. On the prepared skeleton, by raising and depressing the sternum the ribs may be moved upwards and downwards, parallel to one another; the first rib moving as freely as the others. But during life several causes combine to make the first rib more fixed than those which follow: as for example, the weight of the upper extremity, and the strain of the intercostal muscles and ribs beneath. The movements of the thoracic walls in respiration are these:—1st. The antero-posterior diameter is increased by a forward movement of the sternum; the lower end of that bone is raised and advanced, while the upper end, which in easy respiration is at rest, or nearly so, is only raised in full inspiration. 2nd. The lateral diameter of the thorax is increased, both by the elevation and the rotation of the ribs; the first of these movements bringing larger costal arches to a level occupied in expiration by

smaller arches above them; and the second, by the movement or rotation of the ribs round an axis extending from their heads to the sternum, which everts the lower edge of the ribs, and increases the width of their arch outwards. 3rd. The capacity of the thorax, transversely and posteriorly, is increased by the elastic bending of the ribs, as well as the opening of the angle between the ribs and their cartilages, produced by the resistance of the sternum and weight of the limbs to the forward and upward motion of the extremities of the cartilages, and by the inclination backwards given to the middle ribs in their upward movement by the oblique direction of the plane of the costo-transverse articular surfaces. It is further to be noticed, that any considerable elevation of the lowest ribs, instead of increasing, would diminish the capacity of the thorax by raising the diaphragm, and accordingly in inspiration those ribs are drawn backwards and outwards rather than raised. Lastly, it may be remarked, that extension of the vertebral column is an important agent in respiration, for when the column is bent forwards, the ribs are pressed together in the concavity of the curve, and, conversely, when the column is extended the ribs are separated.

The Intercostal Muscles.—The manner in which these muscles act has been a subject of controversy from an early time, and cannot be said to be yet thoroughly understood. Among those who look upon the intercostal muscles as active in respiration, all are agreed that the external muscles are elevators of the ribs, and therefore muscles of inspiration. According to one view, defended by Haller, the external and internal layers have a common action, the decussating fibres acting in the direction of the diagonal between them; while according to another view, that of Hamberger, while the external intercostal muscles are admitted to be elevators, the internal are held to be depressors of the ribs. A more recent modification of these views, which is at present most generally adopted, is that maintained by Hutchison, viz., that the external intercostal muscles, and the parts of the internal intercostals placed between the costal cartilages, elevate the ribs, and that the lateral portions of the internal intercostals act as depressors. This view is founded upon a mathematical demonstration, and may be illustrated mechanically by an apparatus showing, that if two parallel bars, free at one end and attached by joints to a fixed perpendicular at the other, be united by oblique elastic bands, one set of which is directed downwards and away from the fixed upright, while another is directed downwards and towards the upright, the first set of bands will be shortened by the elevation of the bars from an oblique to a horizontal position, and the second set lengthened; whereas the first set will be lengthened and the second shortened by depression of the bars below the horizontal position. It may be objected, however, to this view, that the ribs differ from the supposed bars in respect that they are not rigid, and are not free at either end, but have the greatest extent of motion, at least in some instances, in the middle of their arch, and in the living subject, the ribs, in their elevation, both rotate upon their axis and bend upon themselves, instead of describing a simple upward and downward movement like the bars. The deficiency of the external intercostal muscles in front and of the internal behind, in which situations they would have acted as depressors, seems to point to some sort of combined action of the muscles as elevators of the ribs.

Among the more recent anatomical writers, Henle inclines to Haller's view; Luschka refers to Budge's experiments on the muscles of living animals, as proving that the internal intercostal muscles elevate the ribs (Budge, "Lehrbuch der Physiologie des Menschen," Weimar, 1860, p. 79); and Cruveilhier, founding on the experiments of Beau and Massiat, supports the very different but scarcely tenable view, that the intercostal muscles are not essential agents either in elevating or depressing the ribs, but only act as tensors of the intercostal spaces (op. cit. p. 575).

The levatores costarum have a similar action with the posterior fibres of the external intercostal muscles, and ought therefore to be ranked among the agents of inspiration. The scalene muscles also are usually believed to contribute, even in normal and quiet inspiration, to the support and elevation of the first and second ribs; and it is obvious that the serratus posticus superior must have a similar effect on those upper ribs to which it is attached.

The action of the diaphragm is more easily understood than that of the intercostal muscles. By its contraction and descent its convexity is diminished, the abdominal viscera are pressed downwards, and the thorax expanded vertically. The fibres

arising from the lowest ribs, being directed nearly vertically upwards from their costal attachments, must tend to pull those ribs upwards. The serratus posticus inferior and quadratus lumborum muscles, by opposing the diaphragm, and thus giving it a fixed point on which to descend, become assistant muscles of inspiration. The anterior fibres of the diaphragm being directed more horizontally towards the central tendon, oppose the forward motion of the sternum; hence the sternum becomes arched in patients long subject to asthma. (Hutchison, Article "*Thorax*," in Todd's "Cyclopædia of Anatomy and Physiology;" Meyer, "Physiologische Anatomie.")

In more forcible inspiration, and more especially in severe attacks of dyspnœa, there are called into play other powerful muscles, to secure the inspiratory action of which a fixed attachment must be provided by the support and elevation of the shoulder and arm; among these may be enumerated the serratus magnus and pectoralis minor, acting from the shoulder, and the pectoralis major and latissimus dorsi, acting from the raised arm, which together produce expansion and elevation of the ribs.

Expiration.—In normal and quiet expiration the diminution of the capacity of the chest is mainly, if not wholly, due to the return of the walls of the chest to the condition of rest, in consequence of their own elastic re-action, and of the elasticity and weight of the viscera and other parts displaced by inspiration; the lungs themselves, after distension by air, exert considerable elastic force, and no doubt the ribs and their cartilages re-act strongly by their elastic return from the elevated and bent condition into which they had been thrown by the inspiratory forces. In more forcible acts of expiration, in muscular efforts of the limbs and trunk, and in efforts of expulsion from the thoracic and abdominal cavities, all the muscles which tend to depress the ribs, and those which compress the abdominal cavity, concur in powerful action to empty the lungs, to fix the trunk, and to expel the contents of the abdominal viscera. (See further "Action of the Abdominal Muscles.")

MUSCLES OF THE ABDOMEN.

The muscular wall of the abdomen is formed, in great part of its extent on each side, of three layers of muscle, the fibres of which run in different directions; those of the two most superficial layers lying obliquely, and those of the innermost layer being transverse. In front those three layers of muscle are absent, and are replaced by tendinous expansions, which meet in the middle line, and on either side of that line the fibres of the recti muscles extend in a vertical direction between the tendinous layers, supported usually at the lower end by the pyramidales muscles. Posteriorly the wall is formed in part by aponeurosis, and in part by muscles of which the fibres are chiefly vertical, viz., the muscles of the back, and in front of them the quadratus lumborum.

The *superficial* or *external oblique muscle* (*descending* or *great oblique*) arises from the outer surface of the eight inferior ribs, by slips arranged in a serrated series, five of them meeting with origins of the serratus magnus, and three with origins of the latissimus dorsi. The slips of these two sets of muscles alternate with each other, as the tips of the fingers of one hand may be made to fit in between those of the other, and hence they are said to interdigitate, and are termed digitations. The lower and the upper digitations of the external oblique are connected with the ribs near their cartilages, the others are attached to the ribs at some distance from their extremities; the lowest digitation generally embraces the point of the twelfth rib. The fleshy fibres from the last ribs pass down in nearly a vertical direction to be inserted into the external margin of the crest of the ilium for about the anterior half of its length; all the rest incline downwards and forwards, and terminate in tendinous fibres, which form the broad aponeurosis by which the muscle is inserted.

The *aponeurosis* of the external oblique, wider at the lower than at the upper part, and larger than that of either of the subjacent abdominal muscles, extends inwards towards the middle line in front; at some distance from this, but farther out above than below, it becomes inseparably united with the aponeurosis beneath, and forms a part of the sheath of the rectus muscle in the whole extent of the space from the ensiform cartilage to the symphysis pubis. The upper part of the aponeurosis is connected externally with the larger pectoral muscle. Its lower fibres are closely aggregated together, and extend across from the anterior superior iliac spine to the spine of the pubes, in the form of a broad band, which is called the *ligament* of *Fallopius*, or more commonly of *Poupart*. This band is curved at the middle and outer parts, the convexity of the curve being directed towards

Fig. 197.

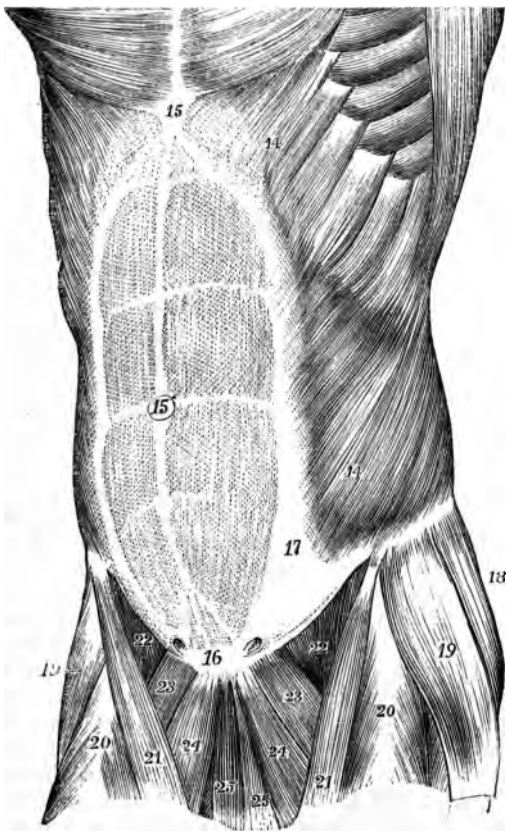


Fig. 197.—Superficial View of the Muscles of the Abdomen, from before. $\frac{1}{5}$

14, external oblique muscle; 15, is placed on the ensiform cartilage at the upper end of the linea aba; 15′, umbilicus; 16, symphysis pubis at the lower end of the linea alba; above 16, the pyramidales muscles are seen shining through the abdominal aponeurosis; from 14 to 17, the linea semilunaris; between this line and the linea alba are seen the transverse lines of the rectus muscle; above 22, the curved margin of Ponpart's ligament; on either side of 16, the external abdominal ring is indicated.

the thigh, a form which is given to it by its connection with the fascia lata of the limb.

Above the crest of the pubes the fibres of the aponeurosis, separating from the inner part of Poupart's ligament, leave between them an oblique opening, the *superficial* or *external abdominal ring*, through which passes the spermatic cord in the male, and the round ligament in the female. The direction of this opening is upwards and outwards, its base being formed by the pubic crest, and its sides by the two sets of diverging fibres called the *pillars*. The upper or internal pillar is attached to the anterior surface of the symphysis pubis, interlacing with the corresponding fibres of the opposite side; the lower or external pillar is formed by Poupart's ligament, near its attachment to the spine of the pubic bone.

A portion of the aponeurosis, which is reflected backwards and outwards along the pectineal line from the attachment of Poupart's ligament to the spine of the pubes, constitutes a small triangular process with a curved external border, not far distant from the femoral ring. This receives the name of *Gimbernat's ligament*. Some curved fibres, directed across the diverging pillars and uniting them together, are named *intercolumnar*. A few of these, descending upon the spermatic cord from the margin of the opening, are prolonged upon that structure as a delicate fascia, named *intercolumnar fascia*. The intercolumnar fibres may be regarded as the lowest of a series of tendinous fibres, which cross the aponeurosis of the external oblique muscle somewhat obliquely over a considerable extent of its surface, and the strongest of which proceed from near the superior spine of the ilium and upper part of Poupart's ligament.

The *deep* or *internal oblique muscle* (*ascending* or *small oblique*), placed under cover of the external oblique, arises by fleshy fibres from the external half or two-thirds of the inner surface of Poupart's ligament, from the iliac crest for two-thirds of its length, and by some fibres from the posterior aponeurosis of the transversalis muscle, in the angle between the crest of the ilium and the outer margin of the erector spinæ muscle. From those attachments the fibres, spreading somewhat, pass to be inserted as follows: the most posterior fibres pass upwards and forwards to the lower margins of the cartilages of the last four ribs, where they are inserted in the same plane with the internal intercostal muscles; those arising further forwards from the crest of the ilium pass, the upper more obliquely, and the rest more horizontally, forwards to end in an aponeurosis in front of the abdomen; those from the front part of the crest extend horizontally inwards to the same aponeurosis; while the fibres from Poupart's ligament, usually paler than the rest, arch downwards and inwards over the spermatic cord, or the round ligament of the uterus, and end in tendinous fibres common to them and the lower part of the transversalis muscle, and hence known as the *conjoined tendon* of these muscles; through the medium of this tendon they are attached to the front of the pubes, and for some distance along the pectineal line, behind and to the outside of Gimbernat's ligament. The spermatic cord and round ligament pass under the arched lower border of the internal oblique and transversalis muscles through the internal or deep abdominal ring.

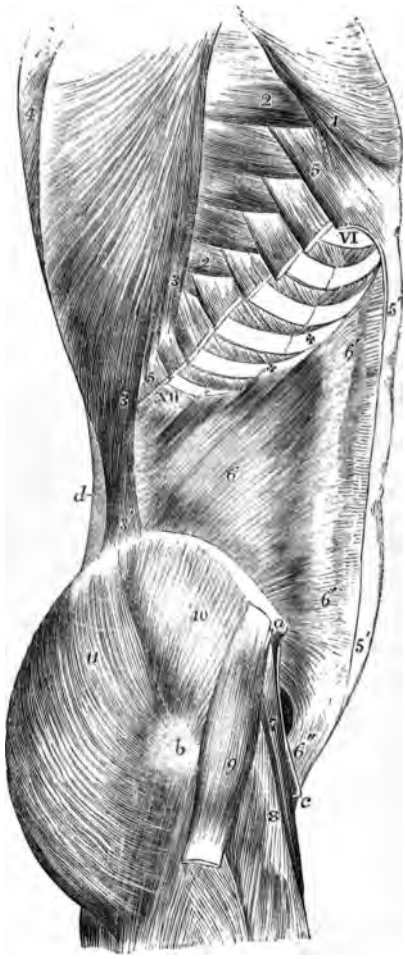
The *aponeurosis* may be regarded as the expanded tendon of the muscle continued inwards in front; it extends from the margin of the thorax to the pubes, and is wider at the upper than at the lower end. At the outer border of the rectus muscle this structure divides into two layers, one passing before, the other behind, that muscle; and the two reunite at its

inner border, so as to enclose it in a sheath. The anterior layer, as already mentioned, becomes inseparably united with the aponeurosis of the external oblique muscle, and the posterior layer is similarly incorporated with that of the transversalis. The upper border of the posterior lamina is attached to the margins of the seventh and eighth ribs, as well as to the ensiform cartilage. This division, however, of the aponeurosis into layers stops short a little above the middle distance between the umbilicus and the pubis, the aponeurosis below that level remaining undivided, and along with

Fig. 198.—Lateral View of the Muscles of the Abdomen and Trunk, the Internal Oblique Muscle having been exposed by the removal of the External Oblique (modified from Henle). $\frac{1}{5}$

a, anterior superior spinous process of the ilium; *b*, trochanter major; *c*, spine of pubes; *d*, lumbar fascia; VI to XII, the sixth to the twelfth ribs; 1, lower part of the great pectoral muscle, where it is attached to the external oblique muscle; 2, 2, lower digitations of the serratus magnus from the fourth to the eighth ribs; 3, lower costal attachments of the latissimus dorsi; 3′, its iliac attachment; 4, trapezius; 5, divided attachments of the external oblique, left in connection with the ribs; 5′, aponeurosis of the external oblique divided in front of the rectus, where it joins the sheath; 6, internal oblique at its middle; 6′, 6, line where it divides to form the sheath of the rectus; + + + XII, its attachments to the four lowest ribs; 6″, the conjoined tendon, and above, and to the outside, the internal inguinal aperture; 7, sartorius; 8, rectus femoris; 9, tensor vaginæ femoris; 10, gluteus medius; 11, gluteus maximus.

Fig. 198.



that of the transversalis muscle to which it is united, passing wholly in front of the rectus muscle. The deficiency thus resulting in the posterior wall of the sheath of the rectus muscle is marked superiorly by a well-defined lunated edge, whose concavity looks downwards towards the pubes—the *semilunar fold of Douglas*.

The internal oblique muscle is almost entirely covered by the external oblique. A small angular portion only near the place where its posterior fibres take their origin, under cover of the latissimus dorsi, is exposed between that muscle and the external oblique, and even this is not constantly found.

The *cremaster*, a muscle peculiar to the male, consists of fibres lying in

series with those of the lower border of the internal oblique muscle. It presents an external and an internal attachment. The external attachment is to Poupart's ligament near its lower part, and there its fibres are continuous with those of the internal oblique muscle; the internal attachment, smaller

Fig. 199.

Fig. 199.—Lateral view of the Trunk, giving a deep view of the Serratus Magnus and Transversalis Abdominis Muscles. $\frac{1}{3}$

The serratus magnus is stretched out by the scapula being drawn away from the ribs. *a*, coracoid process of the scapula; *b*, glenoid cavity; *c*, lower angle; *d*, first dorsal vertebra; *e*, placed on the os pubis, points to the insertion of Gimbernat's ligament; I, VI, XII, the first, sixth, and twelfth ribs; L', first lumbar vertebra; 1, upper portion of the serratus magnus attached to the first and second ribs; 2, second or middle portion attached to the second and third ribs; 3, lower or fan-shaped portion attached to the ribs from the fourth to the ninth; 4, the external intercostal muscles; 5, upper costal origins of the transversalis abdominis; 6, origins of the muscle from the transverse processes of the lumbar vertebræ by the lumbar aponeurosis; 6', part rising from the crest of the ilium; 7, lower portion rising from the upper half of Poupart's ligament, and passing over the internal inguinal aperture; 8, sheath of the rectus muscle opened in its upper part by removing the aponeuroses of the oblique muscles; 9, the same in its lower part left entire at the place where the tendons pass entirely in front of the rectus muscle; 10, the interspinales muscles of the lumbar vertebræ; 11, gluteus minimus; 12, pyriformis.

and less constant, is by means of a tendinous band to the spine and crest of the pubes, close to the insertion of the internal oblique muscle. The superior fibres of the muscle extend between those attachments in a series

of successively longer loops, descending in front of the spermatic cord, a few of them reaching as low as the level of the testicle: the remaining fibres, the greatest number of which descend from the outer attachment, and a few from the inner, spread out inferiorly and are embedded in the substance of a fascia, termed *cremasteric*, which adheres to the fascia propria of the testicle. Sometimes the only fibres developed are a bundle descending from the outer attachment.

In the female there may be almost constantly detected a small bundle of fibres descending on the round ligament of the uterus, which corresponds with the last-mentioned fibres of the cremaster muscle of the male.

The *transversalis abdominis* muscle, subjacent to the internal oblique, arises from the inner surface of the cartilages of the six lower ribs; from a strong aponeurosis attached to the lumbar vertebræ; from the inner margin of the crest of the ilium in the anterior two-thirds of its extent, and from the iliac third of Poupart's ligament. The greater part of the fibres have a horizontal direction, and extend forwards to a broad aponeurosis in front; the lowest fibres curve downwards like those of the internal oblique, and are inserted into the front of the pubes and into the pectineal line, through the medium of the conjoined tendon already described as common to this muscle and the internal oblique.

The *anterior aponeurosis* of the transversalis muscle commences in the greater part of its extent at the distance of about an inch from the outer border of the rectus muscle; but at its upper extremity this aponeurosis is much narrower, and there the muscular fibres of opposite sides approach nearly to the middle line behind the recti muscles. In the greater part of its extent it becomes united with the posterior layer of the aponeurosis of the internal oblique forming the rectus sheath, and inferiorly, where that aponeurosis passes entirely in front of the rectus muscle, it remains blended with it, and passes likewise in front of that muscle.

The *posterior aponeurosis* of the transversalis muscle extends backwards between the last rib and the iliac crest, and opposite the outer border of the erector spinæ muscle, is continuous with the aponeurotic structure which passes to the vertebral column in three layers, commonly named the posterior, middle, and anterior layers of the lumbar aponeurosis. The posterior, or most superficial, of these layers is that previously referred to as being connected with the tendons of the latissimus dorsi and serratus inferior muscles, and which is attached to the spinous processes of the vertebræ. The middle layer, which is the strongest, is attached to the tips and margins of the lumbar transverse processes, and lies between the erector spinæ and quadratus lumborum muscles. The remaining deepest layer, comparatively thin, passes in front of the quadratus lumborum muscle to the roots of the lumbar transverse processes, and at its upper part, where it increases in thickness and is connected with the last rib, it forms, as already mentioned, the ligamentum arcuatum externum of the diaphragm.

The triangularis sterni, when viewed from behind, along with the transversalis abdominis, has the appearance of being a continuation of that muscle upon the wall of the chest, above the diaphragm: hence thename of *transversalis thoracis*, which has sometimes been given to it.

The *rectus abdominis* is a long flat muscle, consisting of vertical fibres, situated at the forepart of the abdomen, within a tendinous sheath formed in the manner already described in the account of the aponeurosis of the

internal oblique muscle; it is separated from the muscle of the other side by a narrow interval, which is occupied by a dense fibrous structure, the *linea alba* afterwards described. It arises from the upper margin of the pubes by a flat tendon consisting of two parts, of which the internal is much

Fig. 200.

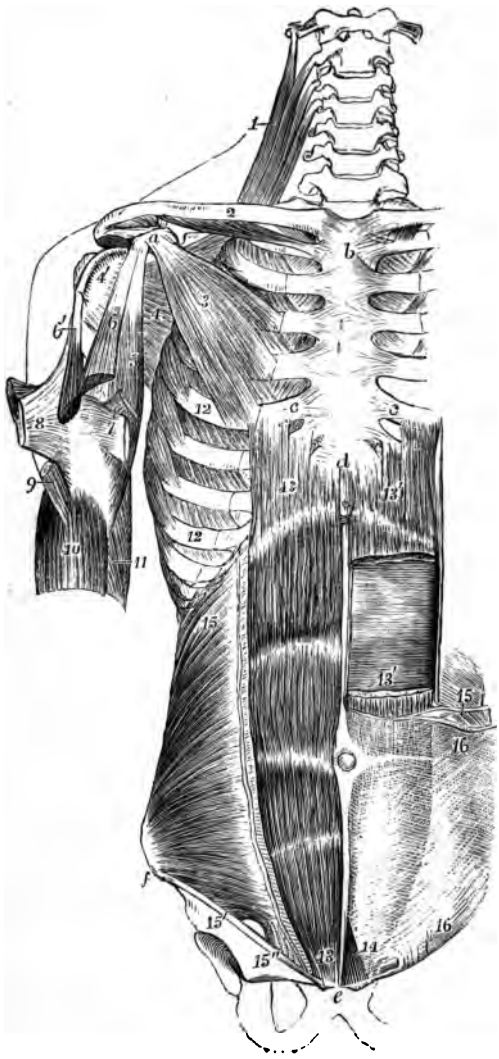


Fig. 200.—Deep Muscles of the forepart of the Trunk and Shoulder. ⅛

The explanation of the references from 1 to 11 has already been given, in the description of fig. 173.

a, coracoid process; *b*, sternum; *c*, *c*, cartilages of the fifth ribs; *d*, ensiform portion of the sternum; *e*, symphysis pubis; *f*, anterior superior iliac spine; 12, on the fifth and eighth ribs, near the insertion of the serratus magnus; 13, on the right side, the rectus abdominis completely exposed; on the left side 13′, 13′, the divided ends of the same muscle, a portion being removed; 14, points to the pyramidalis muscle exposed on the left side; 15, on the right side, the internal oblique muscle; 15′, origin of its lower fibres from the deep surface of Poupart's ligament; 15″, conjoined tendon of the internal oblique and transversalis, descending to the pectineal line; between 15′ and 15″, the internal or deep inguinal aperture, arched over by the muscular fibres; 15, on the left side, cut edge of the internal oblique, shown diagrammatically, to indicate the manner in which its tendon splits to form the sheath of the rectus muscle; 16, the tendon or aponeurosis of the external oblique muscle uniting in front with the sheath of the rectus.

the smaller, and is connected with the ligaments covering the pubic symphysis, while the external one is fixed to the pubic crest. Expanding and becoming thinner at the upper end, the muscle is inserted into the cartilages of three ribs, the fifth, sixth, and seventh, usually by

three distinct parts of unequal size. Some fibres also are generally found attached to the ensiform cartilage.

The fibres of the rectus muscle are interrupted by three or more irregular tendinous intersections, named *lineæ transversæ*. The three which are most constant are placed, one opposite the umbilicus, another on a level with the ensiform cartilage, and the third intermediately between them: and these generally run across the whole muscle. When one or two additional transverse lines occur, they are usually incomplete; one of them is very generally placed below the umbilicus, the position of the other is variable. The intersections do not usually penetrate the whole thickness of the muscle, but are confined chiefly to its anterior fibres, and are firmly united to the anterior wall of the sheath of the muscle, while the posterior surface of the muscle has no attachment to the sheath.

The lineæ transversæ may be regarded as indications of the abdominal ribs of some of the lower animals; they sometimes extend outwards from the rectus, and penetrate partially into the internal oblique.

The *pyramidalis* is a small muscle resting on the lower part of the rectus. It arises from the front of the pubes and the ligaments of the symphysis, and becoming narrow as it ascends over the lower third of the interval between the umbilicus and pubes, is inserted into the linea alba.

The pyramidalis is covered in front by the aponeurosis of the other muscles, and rests posteriorly on the rectus, the size of the lower part of which is augmented when the pyramidalis is wanting.

This muscle is often absent on one or both sides: in some instances it has been found to be double. It occasionally exceeds the length above stated.

The *linea alba* is a white fibrous structure, extended perpendicularly downwards in the middle line from the ensiform cartilage to the pubes. This tendinous band is formed by the union of the aponeuroses of the two oblique and the transverse muscles, the tendinous fibres being continued in a decussating manner from one side to the other. Some longitudinal fibres are distinguishable towards its lower end. It is broader superiorly than inferiorly, and a little below the middle is widened out into a circular flat space, in the centre of which is situated the cicatrix of the *umbilicus*.

The *lineæ semilunares* are the two curved linear spaces on the surface of the abdomen, placed externally to the outer margins of the recti muscles. They are produced by the absence of muscular fibres behind that part of the aponeurotic tendons; they correspond on their inner side to the outer margin of the sheath of the rectus, and on their outer side mainly to the line of termination of the fibres of the oblique muscles in their aponeuroses.

The *quadratus lumborum* is an irregularly quadrilateral muscle, slightly broader below than above, placed between the last rib and the crest of the ilium, close to the vertebral column. It is divisible into two parts. One of these, arising by fleshy and tendinous fibres from the ilio-lumbar ligament, and from the iliac crest for several inches near the place where that ligament is attached, is inserted into the inferior border of the last rib for about half its length, and by four tendinous slips into the transverse processes of the four superior lumbar vertebræ. Another series of fibres, arising by two or three tendinous slips from as many of the inferior transverse processes at their upper margins, passes in front of those inserted into the same processes, and joins with the part of the muscle attached to the rib.

The number of the points of insertion of this muscle to the vertebræ, and the extent of its connection with the last rib, vary in different instances. It is sometimes attached to the body or transverse process of the last dorsal vertebra.

This muscle is placed between the middle and deepest layer of the lumbar aponeurosis, and its inner part is covered in front by the psoas muscle.

Fig. 201.

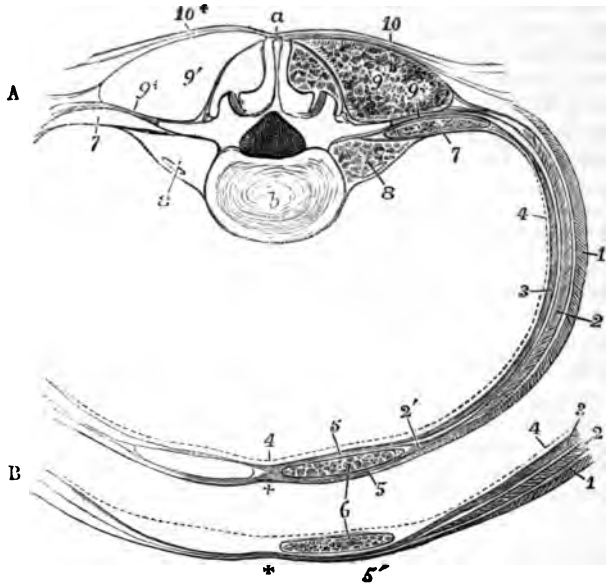


Fig. 201.—Diagram of a transverse section of the Wall of the Abdomen, to show the connections of the Lumbar and Abdominal Aponeuroses, and the Sheath of the Rectus Muscle.

A, at the level of the third lumbar vertebra; B, the fore part, at a few inches above the pubes.

a, spinous process of the third lumbar vertebra; *b*, body; 1, section of the external oblique muscle; 2, internal oblique; 3, transversalis; 4, a dotted line to mark the position of the fascia lining the abdomen; 5, 5, in A, the anterior and posterior parts of the sheath of the rectus, formed by the aponeurosis of the internal oblique splitting at its outer edge 2'; 6, points by two lines to the section of the rectus muscle in A and B; 7, innermost layer of the lumbar aponeurosis, covering in front the quadratus lumborum, and passing to the root of the transverse process; 8, points to the section of the psoas magnus and parvus muscles; 9, the section of the erectores spinæ muscles; 9+, the middle layer of the lumbar aponeurosis passing to the extremity of the transverse process; 10, 10+, the posterior layer of the lumbar aponeurosis, connected with the latissimus and serratus inferior: in A, at the sheath of the rectus, the aponeurosis of the external oblique is seen to unite in front with the sheath, while that of the transversalis is seen uniting with it behind: in B, the section is taken below the semilunar fold of Douglas, where all the tendons pass in front of the rectus as at 5'; the + near this, and in a similar place in A, marks the middle line and the place of the union of the several aponeuroses in the linea alba.

Actions.—The abdominal muscles not only form a great part of the wall to enclose and support the abdominal viscera, but by their contractions are capable of acting successively on those viscera, on the thorax, and on the pelvis. When the pelvis and thorax are fixed, the abdominal muscles constrict the cavity and compress the viscera, particularly if the diaphragm be fixed or be made to descend at the same time, as occurs in vomiting and in the expulsion of the fœtus, the fæces, and the urine.

If the vertebral column be fixed, these muscles press up the diaphragm, draw down the ribs, and contract the lower border of the thorax, and so contribute to expiration; but if the vertebral column be not fixed, the thorax will be bent directly forwards, when the muscles of both sides act, or rotated to either side, should they act alternately. Thus, if the external oblique of the right side be made to act on the thorax, the first effect appears to be that of drawing its margin down towards the pelvis; but, if the effort be continued, the trunk will be rotated towards the opposite side. The left internal oblique may co-operate in this action, for the direction of its fibres coincides with that of the right external oblique.

If the thorax be fixed, the abdominal muscles may be made to act on the pelvis; thus, in the action of climbing, the trunk and arms being elevated and fixed, the pelvis is drawn upwards, either directly or to one side, as a preparatory step to the elevation of the lower limbs.

The attachment of the tendinous intersections of the rectus muscle to the anterior wall of its sheath, causes the formation of corresponding transverse folds during its contraction, and may enable the separate parts of the muscle to act on different portions of the abdominal wall. By the same arrangement, when the oblique and transverse muscles contract, the breadth of the recti will be maintained and even increased; and these muscles will thus be enabled, both in the straight and in the incurved position of the abdominal wall, more effectually to compress the abdominal viscera. The pyramidalis muscle assists the inferior part of the rectus.

FASCIÆ OF THE ABDOMEN.

The *superficial fascia* of the abdomen is usually described as consisting of two layers. One of these, the *subcutaneous layer*, corresponds in its general features with the areolar subcutaneous tissue of other parts of the body, and contains embedded in it a very variable and often large quantity of fat. The other, or *deeper layer*, is of a denser and more membranous structure, contains a considerable amount of yellow elastic tissue in its substance, and is united by intervening fibres, in some places very closely, to the aponeurosis of the external oblique muscle. These two layers are both continuous with the superficial fascia on other parts of the trunk: they can be dissected as distinct layers only on the fore part of the abdomen, and are separated in a more marked manner in the lower part of its wall, where subcutaneous vessels, such as the superficial epigastric and circumflex iliac lie between them. The deep or elastic layer of the superficial fascia is bound down by a thin but dense intervening layer of fibrous tissue to the aponeurosis of the external oblique muscle in two places more particularly, viz., along the linea alba from the umbilicus to the pubes, and in the whole length of Poupart's ligament. At the lower part of the linea alba it sends fibrous and elastic processes towards the dorsum of the penis, which form its so-called suspensory ligaments. By its close union to Poupart's ligament, it comes into relation with the fascia lata of the thigh which is also united to that structure: but in the neighbourhood of the external inguinal aperture it remains free, and is prolonged downwards over the spermatic cord to the scrotum. The subcutaneous layer, losing its fat, is combined with the deeper layer as they both pass to the scrotum, and here the layer which they form acquires a reddish brown colour, and undergoes a modification in structure by being mingled largely with involuntary muscular fibres, and thus forms the *dartos tunic* of the scrotum. Some involuntary muscular fibres also exist in the altered superficial fascia which covers the penis. This covering, on leaving the scrotum posteriorly, becomes continuous with the superficial fascia of the perineum.

The parts of the superficial fascia here described have received minute attention from surgical anatomists, because of their close relation to the seat of hernial tumours: the adhesion of the fascia to Poupart's ligament, and its disposition over the inguinal aperture, spermatic cord, and scrotum, while they prevent the descent upon the thigh of matter which has been effused beneath the fascia, cause it rather to spread upwards upon the abdomen or to take its course downwards upon the scrotum.

The deep layer of the abdominal fascia is also interesting, as corresponding with the *tunica abdominalis*, a strong membrane consisting almost entirely of yellow elastic tissue, which exists in animals, as may be well seen in the horse or ox, and which contributes to the support of the viscera.

Lining membrane of the abdomen.—On the inner surface of the wall of the abdomen is a membranous structure which lines the visceral aspect of the deepest stratum of muscles: it is divisible into two principal parts, the fascia transversalis and fascia iliaca.

The *fascia transversalis* is named from its position on the deep surface of the transversalis muscle. It is strongest and most clearly demonstrable in the lower part, where the muscular and tendinous support is somewhat weaker; and here also it is of particular interest, on account of its forming one of the coverings for inguinal hernia. Followed upwards from this situation the transversalis fascia becomes gradually less strong, and beyond the margin of the ribs it degenerates into a thin covering for the under surface of the diaphragm. Along the inner surface of the iliac crest, between the iliacus and transversalis muscles, the fascia is attached to the periosteum. For about two inches inwards from the anterior superior iliac spine, it is closely connected with the posterior surface of Poupart's ligament, and is there directly continuous with the fascia iliaca, a white line sometimes marking the place of continuity. At this place also, and to the same extent, the fascia lata is closely united with both the fascia transversalis and Poupart's ligament, which thus serves as a line of union of several layers of fascia. About midway between the iliac spine and the pubes, the external iliac artery and vein, as they pass out into the thigh, intervene between the fascia transversalis and the fascia iliaca, and from this point to the edge of Gimbernat's ligament the fascia transversalis is prolonged downwards under the crural arch, and over the artery and vein, forming the anterior portion of the funnel-shaped femoral sheath. This prolongation of the fascia transversalis passes under Poupart's ligament, and is not very closely united with it: it is strengthened by a dense band of fibres which arches over the vessels, and is inserted into the pubic crest and pectineal line behind the conjoined tendon of the transversalis and internal oblique. This band is sometimes called the *deep crural arch*. It includes beneath it, internal to the vessels, a space between Gimbernat's ligament and the vein, sufficiently large to admit the point of the little finger; this is called the *crural ring*, and is the space through which femoral hernia descends. About half way between the anterior superior iliac spine and the symphysis pubis, and about half an inch above Poupart's ligament, the spermatic cord in the male, or the round ligament in the female, pierces the fascia transversalis. The opening thus made is called the *internal* or *deep abdominal ring*, to distinguish it from the external or superficial ring in the aponeurosis of the external oblique muscle; the fascia above and internal to it is thin, but below and external to it is firm and thick, and forms a distinct crescentic margin, over which the cord or round ligament passes; from the borders of the opening a delicate funnel-shaped covering, the *infundibuliform fascia*, is prolonged downwards on the emerging struc-

ture, and forms in cases of oblique hernia one of the coverings of the tumour.

The *fascia iliaca*, more limited in extent, but stronger than the fascia transversalis, lines the back part of the abdominal cavity, and covers not only the muscle from which it derives its name, but also the psoas. The densest portion of its fibres is stretched transversely from the iliac crest, over the margin of the psoas muscle to the brim of the pelvis, where it is intimately blended with the periosteum. Superiorly, this membrane, becoming much weaker, is connected internally with the sacrum, and by small and distinct processes with the intervertebral substances and the neighbouring margins of the lumbar vertebræ; and finally it becomes blended with the fascia which covers the diaphragm and forms the ligamentum arcuatum externum. The external iliac vessels lie in front of this part of the iliac fascia. To the outer side of those vessels, the fascia turns forwards to be connected with Poupart's ligament and the fascia transversalis, as already described; to the inner side of the femoral vein it is attached to the ilio-pectineal line, where also the fascia lata, being traced upwards, is found to terminate; and between these two points, namely, behind the femoral vessels, it continues downwards over the margin of the pelvis, forming the back part of the sheath of those vessels, in the same manner as its fore part is formed by the fascia transversalis.

The psoas parvus is closely connected with the iliac fascia, by means of an expansion of its tendon.

At the back part of the abdomen is the aponeurosis of the quadratus lumborum muscle, forming the anterior layer of the lumbar aponeurosis; this, together with the posterior and middle layers, has been already described along with the transversalis muscle, with the aponeurotic origin of which they are all connected.

FASCIÆ OF THE PERINÆUM.

As a knowledge of the disposition of the fasciæ of the perinæum and pelvis assists the comprehension of the attachments and relations of the muscles of those regions, the fasciæ will here be first described.

Superficial Fascia.—In the posterior half of the perinæum the subcutaneous fat is continued deeply into the ischio-rectal fossa, the pyramidal space intervening between the obturator fascia and the levator áni muscle. In the anterior half of the perinæum, beneath the subcutaneous fat, is placed a special layer of fascia, continuous with the dartos, the *proper superficial perinæal fascia*, sometimes called *fascia of Colles*. This fascia is bound down on each side to the margin of the pubic arch as far back as the ischial tuberosity; posteriorly, along a line from the ischial tuberosity to the central point of the perinæum, it turns round the posterior margin of the transversus perinæi muscle to join the sub-pubic fascia, to be presently described. From its deep surface likewise, an incomplete septum in the middle line dips down to the urethra and passes forwards into the scrotum. It thus happens that air blown in beneath the proper perinæal fascia on one side passes forwards and distends the scrotum to a certain extent on that side; it may then penetrate to the other also, and if injected with sufficient force may reach the front of the abdomen and travel upwards beneath the superficial fascia; but it neither passes backwards to the posterior half of the perinæum nor down upon the thighs. The same course is followed by urine or matter extravasated beneath the proper perinæal fascia.

The *deep perinæal* or *sub-pubic fascia* is stretched across the pubic arch on the deep surface of the crura of the penis and the bulb of the urethra. It consists of two distinct layers of strong fibrous membrane, separated by intervening structures. The *anterior layer*, or *triangular ligament of the urethra*, attached to the inferior margin of the symphysis pubis and to the rami of the pubic and ischial bones, and extending in the middle line back to the central point of the perinæum, is perforated about an inch from the symphysis by the urethra, immediately before its expansion into the bulb, and above and in front of this by the dorsal vein of the penis in the middle line, and by the pudic arteries and nerves on each side. At its posterior and inferior extremity it is connected with the deep layer, and with the recurved margin of the perinæal fascia. Between the two layers of the subpubic fascia are placed the membranous portion of the urethra, the deep transverse and constrictor muscles of the urethra, and Cowper's glands, together with the pudic arteries and nerves and the arteries of the bulb. The deep layer consists of a right and left lateral half, which are separated in the middle line by the urethra, close to the neck of the prostate, and are continued into the capsule of that gland. This layer of fascia is superficial to the anterior fibres of the levator ani muscle, which lie between it and the pelvic fascia, and is connected, not only with the superficial layer, but likewise with a thin web of areolar tissue which lies on the surface of the levator ani muscle, and is distinguished as the *anal fascia*.

In the female the sub-pubic fascia is divided in the middle by the vagina.

FASCIÆ OF THE PELVIS.

The fascia lining the pelvis is described in three parts, viz., the upper part, or *undivided pelvic fascia*, and the two lower—the recto-vesical fascia, and the obturator fascia. The first of these is divided into the other two at the level of a white band of fibres, stretched from the lower part of the symphysis pubis to the spine of the ischium. The space between those two fasciæ is occupied by the levator ani and the fat and other contents of the ischio-rectal fossa.

a. The *pelvic fascia* is attached at the side superiorly for a short space to the brim of the pelvis, but in front of the line of its osseous attachment it inclines downwards towards the lower part of the symphysis pubis, following the margin of the obturator internus muscle. Anterior to the spine of the ischium, it lies between the obturator internus and the peritoneum, and at the back part of the pelvis is continued as a thin membrane over the pyriformis muscle and the sacral nerves, and is perforated by branches of the internal iliac artery and vein.

b. The *recto-vesical fascia* is the direct continuation of the pelvic fascia downwards and inwards to the viscera, below the level of the white line previously mentioned ; it descends, immediately in contact with the inner surface of the levator ani muscle, to the prostate gland, the urinary bladder, and the rectum. On reaching those organs it spreads over them, and to some extent encases them. Close to the symphysis pubis, a short band is directed backwards above the prostate gland, to the bladder, with which it is intimately connected. A similar band exists at the opposite side of the symphysis pubis, and the two are separated by a narrow depression, in which the dorsal veins of the penis lie, after entering the pelvis. The bands in question are named the *anterior true ligaments of the urinary*

bladder. At the place where it is reflected inwards to the side of the bladder, it forms the *lateral true vesical ligament.* At the side of the bladder and prostate, the recto-vesical fascia gives a prolongation forwards on the veins (prostatic) which cover the prostate, and is firmly adherent to the capsule of that organ, except at its base, where an angular furrow, occupied by large veins, exists between the prostate and bladder. Into this furrow the incision for lithotomy ought not to extend, on account of the danger from wounding the veins and from the infiltration of urine. A portion of the recto-vesical fascia invests the vesiculæ seminales, and is extended across between the bladder and the rectum; continuing into the membrane of the opposite side, it supports the bladder, and separates that organ from the intestine. On the rectum the fascia is also reflected upwards and downwards, gradually degenerating into a thin membrane over the surface of the bowel, as it likewise does on the bladder.

c. The *obturator fascia* is a membrane stretched over the lower part of the surface of the obturator internus muscle within the pelvis. It is connected superiorly with the white band before referred to, which consists indeed of its superior fibres, and it is attached in the rest of its circumference to the rami of the pubis and ischium, the ischial tuberosity, and the greater and lesser sacro-sciatic ligaments. It lies between the obturator internus muscle and the ischio-rectal fossa, and presents in its substance towards the muscle a canal, which contains the internal pudic artery and nerve in their course to the perinæum.

The obturator fascia is sometimes included in the description of the pelvic fascia while the recto-vesical is considered as an offset from it. It will be found, however, on dissection, that the recto-vesical fascia is always most directly continuous with the pelvic fascia, and that the obturator fascia is only loosely connected with it. Indeed, the fibres of the levator ani muscle in most cases pass upwards to some extent beyond the white line, and thus separate the obturator from the pelvic fascia.

The *ischio-rectal fossa* is a pyramidal space occupied by subcutaneous fat. It is bounded externally by the obturator fascia, posteriorly by the gluteus maximus muscle and great sacro-sciatic ligament, and internally by the recto-vesical fascia; anteriorly, its base is limited by the margin of the perinæal and the sub-pubic fasciæ.

In the female the pelvic fascia is connected with the vagina in the same manner as with the other pelvic organs.

MUSCLES OF THE PERINÆUM.

The muscles of the perinæum differ somewhat in the two sexes, and must therefore be separately described in each. In both sexes they may be divided into two groups according as they are more immediately connected with the lower orifice of the alimentary canal or with the genito-urinary outlet. In both groups superficial and deep muscles are to be distinguished.

A.—IN THE MALE.

a. ANAL GROUP.—The *internal* or *circular sphincter* is a thick ring of unstriped muscle connected with the lowest circular fibres of the rectum, which will fall more naturally to be considered along with the anatomy of that organ.

The *superficial* or *external sphincter* is a thin layer of fibres placed immediately beneath the skin surrounding the margin of the anus. It is elliptical in form, about half an inch in breadth on each side of the anus, and is attached posteriorly by slight tendon to the tip and back of the coccyx; passing forwards on each side of the anus, it becomes blended anteriorly with the transverse and the bulbo-cavernosus muscles at the *central point of the perinæum*, a name given to the depressed spot situated in the male between the anus and the bulb of the urethra, and in the female between the anus and vulva.

Fig. 202.

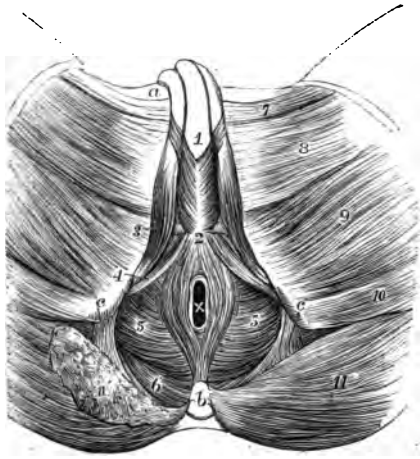


Fig. 202.—SUPERFICIAL VIEW OF THE MUSCLES OF THE PERINÆUM IN THE MALE (modified from Bourgery). ¼

a, crest of the pubis; the penis cut short at this place; *b*, coccyx; *c*, placed on the tuberosity of the ischium, points by the line to the greater sacro-sciatic ligament; ×, placed within the anus; 1, placed on the spongy body of the urethra, in front of the bulbo-cavernosus muscles; 2, placed on the central point or tendon of the perinæum, marks the posterior extremity of the same muscles; 3, ischio-cavernosus; 4, transversus perinæi; 5, levator ani; from 2 to *b*, elliptical sphincter of the anus; surrounding ×, the circular sphincter is indicated; 6, coccygeus muscle; 7, adductor longus; 8, gracilis; 9, adductor magnus; 10, semitendinosus and biceps; 11, on the left side, the gluteus maximus entire; 11′, the same cut on the right side, so as to expose a part of the coccygeus muscle.

The *levatores ani* and *coccygei* are two expanded muscles continuous one with the other, which together form a floor of support for the pelvic viscera, and close in a great measure the lower orifice of the pelvis.

The *levator ani* arises in front from the posterior surface of the pubes, near the symphysis and midway between its upper and lower borders; behind from the spine of the ischium, and between those points from the pelvic fascia along the line of attachment of the obturator fascia. Some of its fibres are also traceable upwards in the substance of the pelvic fascia above the level of the obturator.

From this extensive origin the fibres of the levator proceed downwards and inwards towards the middle line of the floor of the pelvis. Its posterior fasciculi are inserted upon the side of the lower end of the coccyx; the bundles immediately in front of the coccyx unite in a median raphé with those of the opposite sides as far forward as the margin of the anus; the middle and larger portion of the muscle is prolonged upon the lower part of the rectum, where it is connected with the fibres of the external sphincter, and slightly with those of the internal; and lastly, the anterior muscular bundles pass between the rectum and the genito-urinary passages, and descending upon the side of the prostate, unite beneath the neck of the

bladder, the prostate, and the neighbouring part of the urethra, with corresponding fibres from the muscle of the opposite side, and blend also with those of the external sphincter and deep transverse perinæal muscles.

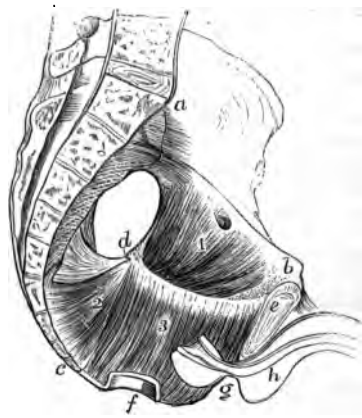
The anterior portion of the levator ani, which arises from the ramus of the pubes, close to the symphysis and above the pubic arch, and also from the adjacent fasciæ, is sometimes separated at its origin by areolar tissue from the rest of the muscle. From this circumstance, and from its connection with the prostate gland, it was described by Santorini, and since by Albinus and Sœmmerring, as a distinct muscle, under the name of the *levator prostatæ*. Its fibres pass backwards parallel with the middle line.

The upper or pelvic surface of the levator ani is in contact with the recto-vesical fascia, the capsule of the prostate, and the lower end of the rectum. The under, or perinæal surface, invested by the thin anal fascia, is covered by the fat which occupies the ischio-rectal fossa. The posterior border is continuous with the coccygeus.

Fig. 203.—Left half of the Male Pelvis, to show the Levator Ani and Coccygeus Muscles (after Cloquet). ½

a, the promontory of the sacrum; *b*, the crest of the pubis; *c*, the last bone of the coccyx; *d*, the spine of the ischium; *e*, the symphysis pubis; *f*, a small portion of the anal part of the rectum; *g*, half the prostate gland; *h*, half the bulb and a portion of the penis with the urethra, &c.; 1, upper part of the obturator internus muscle exposed by removing from within it the pelvic fascia; 2, coccygeus muscle, and above it and between it and *d*, the sacro-sciatic ligaments; 3, inner surface of the levator ani; the white line extending between *d* and *e*, shows the place of its origin from the fascia of the pelvis; below is shown the descent of its fibres to the anus and to the portions of the perinæum before and behind it.

Fig. 203.



The *coccygeus* muscle is composed of fleshy and tendinous fibres, forming a thin, flat, and triangular sheet, which arises by its apex from the spine of the ischium and the lesser sciatic ligament, and is attached along its base to the border of the coccyx and the lower part of the sacrum. The fibres of this muscle diverge as they approach the middle line, while those of the levator ani rather converge as they descend.

The internal or pelvic surface of this muscle assists in supporting the rectum; its external or under surface rests on the front of the sacro-sciatic ligaments, and on the gluteus maximus muscle.

The levatores ani and coccygei muscles together have been named somewhat appropriately by Meyer, the pelvic diaphragm.

b. Genito-urinary Group.—Covered by the special fascia of the perinæum are three muscles, placed superficially—the transverse (superficial transverse), the ischio-cavernosus, and the bulbo-cavernosus; while situated more deeply between the superficial and deep layers of the sub-pubic fascia, are the deep transverse muscle and the constrictor of the urethra, sometimes described as one muscle under the name of compressor of the urethra.

The *transversus perinæi* muscle arises from the inner surface of the pubic arch, near the ischial tuberosity, and is directed obliquely forwards and inwards to unite with the muscle of the opposite side, as well as with the sphincter ani and bulbo-cavernosus at the central point of the perinæum. It lies immediately in front of the line where the perinæal dips back to join the sub-pubic fascia. It is sometimes absent, and at other times one or more small muscular slips are found lying on the same plane with it, in front or behind.

The *ischio-cavernosus*, or erector penis muscle, embracing the crus penis, arises from the inner part of the tuber ischii, behind the extremity of the crus penis, and from the pubic arch along the inner and outer sides of the crus. From this origin the fleshy fibres are directed forwards to a tendinous expansion which is spread over the lower surface of the crus penis, and is inserted into the under and outer surfaces of that body towards the fore part.

This muscle serves to compress the crus penis, with which its tendinous fibres are blended, and thus it contributes to produce, or at least to maintain, the erection of the penis.

The muscles of the two sides have been described by Krause as in some cases connected by a thin tendinous expansion, which, according to that anatomist, extends along the outer side of the penis over the dorsal surface of the organ, and at the same time over the vessels lying upon it (Müller's Archiv, 1832): but this connection between the muscles has been in vain sought for by Theile and by Kobelt (Die männlichen und weiblichen Wollust-Organe, 1844). By Houston there have also been described (Dublin Hosp. Reports, vol. v.), under the name of *compressores venæ dorsalis penis*, two slips of muscle, separated from the erectores penis on each side by an interval, though apparently belonging to them. They are said to arise from the pubic arch, above the origin of the erector muscles and the crura of the penis, and, passing upwards and forwards, are inserted above the dorsal vein, by joining each other in the middle line. These muscles, which are well developed in the dog and several other animals, are by no means constant in the human subject.

The *bulbo-cavernosus*, accelerator urinæ, or ejaculator seminis, may be considered as a single muscle, consisting of two symmetrical parts.

The fleshy fibres of the muscle take origin behind from the central tendon of the perinæum, and from a median tendinous raphé interposed between the two halves of the muscle. The larger number of the fibres are directed round the bulb and the adjoining part of the corpus spongiosum urethræ, and join above that body with those from the opposite side by a strong aponeurosis. At the fore part, a portion of the muscle passes over the sides of the corpus cavernosum, and is attached to that body in front of the erector penis: from its insertion a tendinous offset is said to be prolonged over the dorsal vessels of the penis (Kobelt). The posterior fibres, shorter than the anterior, are inserted into the front of the triangular ligament.

The fibres which invest the most prominent part of the bulb are more or less distinct from those contiguous to them, and have been described by Kobelt as forming a separate muscle, to which he has given the name *compressor hemisphæriûm bulbi*. The fibres of this muscular slip are connected by a small tendon, above the urethra, with the corresponding part of the opposite side.

This muscle compresses the bulb and the adjoining part of the corpus spongiosum of the urethra, so as to evacuate fluid lodged in the canal, as well as to increase the turgescence of the glans during erection.

The *deep transversus perinæi* muscle is a thin rather inconstant fasciculus, which, arising from the margin of the pubic arch, is directed inwards and

meets with its fellow of the opposite side behind the bulb, at the central point of the perinæum. Its fibres conceal Cowper's gland.

The *constrictor urethræ* muscle consists of a number of transverse fibres extending across the arch of the pubis, some of them above and others below the membranous portion of the urethra, and closely embracing it. In some bodies a tendinous raphé, placed over the middle of the urinary canal, separates each stratum into lateral halves.

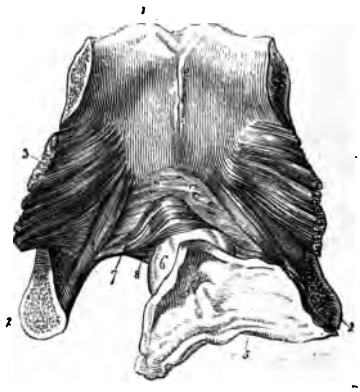
This muscle rests in contact with the deep layer of the triangular ligament, which separates it from the anterior fibres of the levator ani.

The transverse constrictor of the urethra was known to Santorini. One of the representations of it, contained in his posthumous work, has been copied for the woodcut (Fig. 204). Indistinctly or partially noticed by other anatomists, the muscle was first fully described by Guthrie; and the whole of the muscular structure connected with the membranous part of the urethra was examined about the same time by Müller, but the results were not published till a later period. (Guthrie, "Anatomy and Diseases of the Neck of the Bladder," &c., 1834; Joannes Müller, "Ueber die organischen Nerven der erectilen männlichen Geschlechts-Organe," &c., 1836.)

Fig. 204.—Posterior View of the Pubes, with part of the Bladder and Urethra attached (from Santorini). ½

1, body; 2, rami of the pubes; 3, obturator internus muscle; 5, portion of the fundus and neck of the bladder laid open; 6, the prostate gland; 7, transverse fibres of the compressor urethræ muscle, passing above the urethra; 8, similar fibres passing beneath that canal.

Fig. 204.



Circular fibres of Santorini (stratum internum circulare, Müller).—Beneath the transverse muscle just described is a series of circular involuntary muscular fibres, entirely surrounding the membranous part of the urethra: these are continuous behind with the circular fibres of the prostate, and are referred to in the description of that body. (See Structure of the Prostate.)

A pubo-urethral muscle was described by James Wilson (Medico-Chirurgical Trans., London, vol. i. p. 176), and is sometimes referred to as Wilson's muscle, but has not been recognised as a separate muscle by succeeding anatomists who have given special attention to the subject of the muscular structures round the urethra. An unstriped pubo-vesical band has been described, descending from the back of the symphysis to the neck of the bladder (Luschka).

B.—IN THE FEMALE.

In the female the anterior fibres of the *levator ani* embrace the vagina as they do the prostate in the male.

The *transversus perinæi* and the *sphincter ani* are arranged nearly in the same manner as in the male.

The *erector clitoridis* differs from the erector penis of the male by its smaller size alone.

The *sphincter vaginæ* is attached behind to the central point of the perinæum, in common with the sphincter ani and transversus perinæi muscles; its fibres open out to surround the vaginal orifice and vestibule, closely embracing on the outer side the two bulbs of the vestibule; again approaching each other in front, they become narrow, and are inserted upon the corpora cavernosa of the clitoris, a fasciculus crossing over these and including the vena dorsalis. The two halves of this elliptical muscle appear to correspond strictly to those of the bulbo-cavernosus muscle in the male.

Fig. 205.

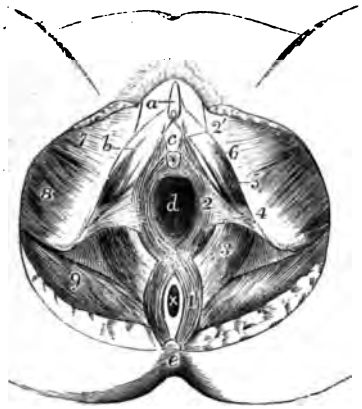


Fig. 205.—Muscles of the Perinæum in the Female. ½

a, clitoris; *b*, crus clitoridis; *c*, is placed in the vestibule above the orifice of the urethra; *d*, vagina; ×, anus; *e*, coccyx; 1, external sphincter ani muscle; 2, sphincter vaginæ; 2′, a few of its fibres prolonged to the clitoris; 3, levator ani; 4, on the left ischial tuberosity, points to the transversus perinei (the inner fibres of this muscle are represented too far forwards in the figure); 5, 6, ischio-cavernosus; 7, gracilis; 8, adductor magnus and semitendinosus, &c.; 9, gluteus maximus.

A *deep transverse* muscle, corresponding to part of the constrictor urethræ of the male, has been described as resting on the pubic surface of the female urethra.

MUSCLES OF THE LOWER LIMB.

The muscles which pass between the trunk and the lower limb, viz., the psoas, pyriformis and coccygeus, are so few in number and so intimately connected with others, that it is inexpedient to describe them as a distinct group, as has been done in the case of the more numerous and considerable muscles which attach the upper limb to the trunk.

MUSCLES OF THE HIP AND THIGH.

Gluteal Region.—The muscles of this region are the three glutei, the pyriformis, the obturator externus, the obturator internus with the gemelli, and the quadratus femoris.

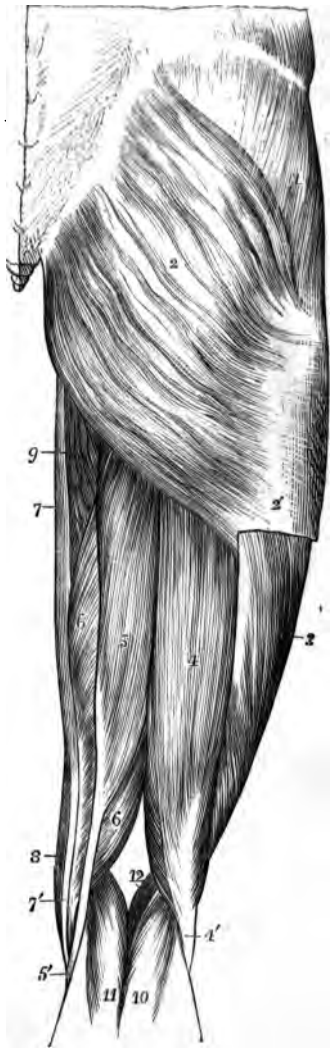
The *gluteus maximus* is a very large and coarsely fasciculated muscle, somewhat quadrilateral in shape, which forms the greatest prominence of the gluteal region posteriorly. It arises from the posterior fifth of the iliac crest, and the irregular rough surface of the ilium subjacent to that part; from the posterior surface of the last piece of the sacrum; from the great sacro-sciatic ligament and the side of the coccyx; and between the sacrum and the ilium, from the aponeurosis of the muscles of the back. Thence it passes downwards and outwards; the fibres of its lower third are inserted

into an elongated rough impression, extending between the base of the great trochanter and the linea aspera ; and those of the upper two-thirds into a thick tendinous structure, which covers the great trochanter, and joins the fascia lata of the thigh : a few of the lowest fibres terminate also in the fascia.

Fig. 206.—Superficial Muscles of the Hip and Thigh, seen from behind. ¼

1, gluteus medius, covered by the strong fascia lata ; 2, middle of the gluteus maximus ; 2′, placed on the fascia lata below the place where the gluteus maximus is inserted into it, and above the insertion of the muscle into the femur ; 3, vastus externus ; 4, biceps flexor cruris ; 4′, tendon of the biceps, receiving on its outer side the oblique fibres of the short part ; 5, semitendinosus ; 5′, its tendon near the insertion ; 6, semimembranosus, its tendon of insertion is seen between 5′ and 7′ ; 7, gracilis ; 7′, tendon of the gracilis near its insertion ; 8, small part of the sartorius ; 9, small portion of the adductor magnus ; 10, outer, and 11, inner head of the gastrocnemius ; 12, placed in the popliteal space, points to the origin of the plantaris.

Fig. 206.



At the upper and lower borders of this muscle, the fascia lata, or aponeurosis of the limb, splits into two thin layers, which are continued, one on the deep, and the other on the outer surface, so as to enclose the muscle. A few fibres on the upper border of the muscle arise from the deeper of those two layers: the lower border, longer and looser, lies in the fold of the nates. The deep surface rests on the gluteus medius and pyriformis muscles, the tendon of the obturator internus, with the two gemelli, the quadratus femoris, a small portion of the adductor magnus, the great trochanter, the ischial tuberosity, and the origins of the hamstring muscles; it covers also the sciatic artery and nerves as they emerge from the pelvis below the pyriformis, the superficial branch of the gluteal artery passing out above that muscle, and the pudic artery and nerve lying behind the spine of the ischium.

Between the tendon of the muscle and the great trochanter of the femur, are placed two or three synovial bursæ, or a single multilocular bursa of large size. A bursa is also situated between the muscle and the tendon of the vastus externus, and another separates it from the tuber ischii.

The great size of the gluteus maximus, and the consequent prominence of the buttock, is a characteristic of man as compared with those animals which most nearly approach him in general structure.

The *gluteus medius*, covered partly by the gluteus maximus, partly by the fascia lata, arises from the surface of the dorsum ilii above the superior

curved line, and in front of the gluteus maximus, from the strong fibres of the fascia lata covering its outer surface. The muscular fibres converge as they descend, the anterior fibres passing obliquely backwards, the posterior fibres obliquely forwards, and terminate in a fan-shaped tendon, which, becoming narrowed and thick, is inserted into the oblique line directed downwards and forwards on the outer surface of the great trochanter. The tendon is separated by a small bursa from the upper part of the trochanter. Anteriorly there is no separation between this muscle and the gluteus minimus on which it lies, the two muscles running into one another at their common anterior border, and separating only at their tendons of insertion.

Between this muscle and the gluteus minimus are the gluteal nerve and deep branches of the gluteal artery.

Fig. 207.

Fig. 207.—Deep Muscles of the Hip and Pelvis on the left side, from behind. ¼

The gluteus maximus and the muscles ot the thigh have been removed. 1, gluteus medius; 2, pyriformis; 3, gemellus superior; 4, gemellus inferior; 5, obturator internus, seen partially within the pelvis, and, after issuing by the lesser sciatic notch, between the gemelli muscles; 6, quadratus femoris; 7, tendon of the obturator externus between the gemellus inferior and quadratus.

The *gluteus minimus*, covered by the preceding muscle, arises from the whole space on the dorsum ilii between the superior and inferior curved lines. The fibres, converging as they descend, terminate in an aponeurotic expansion, superficial to the muscle, and become narrowed into a tendon which is inserted into an impression on the anterior border of the great trochanter. The tendon is bound down to the prominence of the trochanter by a strong fibrous band which joins it from the upper margin of the capsule of the hip-joint. A synovial bursa is interposed between the tendon and the trochanter.

The *pyriformis* muscle arises within the pelvis by three fleshy digitations from the second, third, and fourth divisions of the sacrum, between the anterior sacral foramina, slightly from the deep surface of the iliac bone, near the sacro-sciatic notch, and from the sacro-sciatic ligament. The muscle passes out of the pelvis by the great sacro-sciatic notch, and is inserted by a rounded tendon into the upper border of the great trochanter, being bound down for some distance from the point of its final insertion to the subjacent tendon of the obturator internus and gemelli muscles.

The pyriformis muscle, after escaping from the pelvis, is in contact by its upper border with the gluteus medius and minimus, the gluteal vessels and nerve intervening; and by its lower border with the superior gemellus muscle, the sciatic vessels and nerves, which emerge beneath it, lying between. The muscle is frequently pierced by part of the great sciatic nerve, and is thus divided more or less completely into two parts.

The *obturator internus* muscle, in great part lodged within the pelvis, arises from the deep surface of the obturator membrane; from the fibrous arch which completes the canal for the obturator vessels and nerves; from a narrow strip of the bone internal to the obturator foramen; from the posterior surface of the membrane occupying that aperture, extending on the bone downwards to the outlet, backwards as far as the sciatic notch, and upwards to the brim of the pelvis; it also arises to some extent from the obturator fascia, which is in contact with the deep surface of the muscle. Its fibres converging as they proceed backwards from this origin, the muscle emerges from the pelvis by the small sacro-sciatic foramen, turns over on the trochlear surface of the ischium, and is directed outwards, to be inserted, in connection with the gemelli, into the upper part of the digital fossa of the great trochanter. The tendon of the muscle is formed by the union of four or five bands, occupying the surface of the muscle which is towards the bone, and lying side by side as they turn over the trochlear groove: their motion in that groove is facilitated by a synovial bursa, which sends in processes between them, and by a thin coating of cartilage on the trochlear surface of the bone. Another bursa, of much smaller size, elongated and narrow, is placed between the tendon and the fibrous capsule of the hip-joint. These bursæ are sometimes continuous with one another.

The *gemelli* (gemini) are two small narrow muscles, consisting chiefly of fleshy fibres extended horizontally at each side of the tendon of the obturator internus; and they are named from their position above and below that tendon. The *gemellus superior*, which is usually the smaller muscle, arises from the ischial spine; the *gemellus inferior* takes origin from the upper and back part of the tuberosity of the ischium. Passing outwards, they join the tendon of the internal obturator muscle, which is placed between them, covering and concealing it more or less, and along with it are inserted into the digital fossa of the trochanter. Some of their fibres, especially from the superior gemellus, run obliquely into the tendon of the obturator.

The superior gemellus is placed immediately below the pyriformis; the inferior gemellus is above the quadratus femoris, and at its insertion is close to the tendon of the obturator externus muscle; both muscles are in contact with the synovial bursæ of that tendon. These muscles may be regarded as portions of the obturator internus arising external to the pelvis. The gemellus superior is often very small, and in some cases is altogether absent.

The *quadratus femoris*, of an oblong figure, arises from the external border of the tuber ischii, and proceeding horizontally outwards, is inserted into the greater part of the linea quadrati on the posterior surface of the great trochanter of the femur.

Superiorly this muscle is close to the inferior gemellus. Its inferior border is in contact, at its origin, with the descending fibres of the adductor magnus, and at its insertion with the superior or horizontal fibres. It conceals the outer part of the obturator externus, and also the lesser trochanter, which is separated from it by a small bursa.

The *obturator externus*, arising from the anterior two-thirds of the surface of the obturator membrane, and from the outer surface of the rami of the pubes and ischium as far as the margin of the thyroid foramen, encroaching also a little upon the body of the pubes, and spreading towards the tuberosity of the ischium, extends horizontally outwards and backwards, converging to a tendon which is directed along the under and hinder surface of the neck

of the femur to be inserted into the trochanteric fossa below the obturator internus and gemelli.

POSTERIOR FEMORAL REGION.

(The Hamstring Muscles).

Fig. 208.

At the back of the thigh are three long flexor muscles of the knee-joint, viz., the biceps, semitendinosus, and semimembranosus.

The *biceps flexor cruris* consists of two parts, arising one from the hip-bone, the other from the femur, and uniting inferiorly to terminate on the fibula. The *long head* arises by a tendon common to it and the semitendinosus from the most prominent part of the ischial tuberosity, and the muscular fibres terminate below the middle of the thigh in an aponeurosis which is continued down into the tendon of insertion. The *short head* arises from the rough surface of the linea aspera in its whole extent, from a part of the line leading from thence to

Fig. 208.—Deep Muscles of the Right Hip and Thigh, from behind. ¼

a, anterior, *a'*, posterior superior spine of the ilium; *b'*, posterior inferior spine; *c*, *c*, great and small trochanter; *d*, symphysis pubis; *e*, tuberosity of the ischium; *f*, flat or popliteal surface of the femur; *g*, head of the fibula; 1, gluteus minimus; 2, obturator internus passing out of the pelvis by the lesser sciatic notch to the digital fossa of the trochanter: the gemelli muscles have been removed; 3, obturator externus; 4, small part of the back of the pectineus and adductor brevis; 5, origin of the adductor magnus from the lower part of the ischial tuberosity; 5', 5', line of insertion of this muscle on the linea aspera, in which are seen three arched tendinous intervals for the passage of the perforating vessels; 5'', tendon of insertion into the inner tuberosity of the femur; between the lower 5' and 5'', the interval through which the femoral vessels pass into the popliteal space; the upper 5' is placed upon the cut end of quadratus femoris; 6, vastus externus; 7, vastus internus; 8, femoral head of the biceps femoris: the lower part is represented as passing too far inwards; 8', its ischial head, cut short; 9, plantaris muscle; at its upper end the outer head of the gastrocnemius; the figure 5'' is upon the cut inner head; 10, popliteus, cut short below; 11, tendon of the semimembranosus; 12, upper part of the soleus.

the outer condyle, and from a part of the adjacent flat surface of the femur

also from the external intermuscular septum between it and the vastus externus muscle, and terminates on the same aponeurosis as the long head. The inferior tendon is inserted into the head of the fibula by two portions, between which is attached the external lateral ligament of the knee-joint, being separated from them by a synovial bursa. Some of the fibres of the tendon, passing forwards and downwards, are inserted into the front of the tibia, and others passing backwards strengthen the fascia of the leg.

The *semitendinosus* muscle, arising from the tuberosity of the ischium by the tendon common to it and the biceps, for a distance of about three inches, descends on the back of the thigh, and terminates below the middle in a long, rounded, and slender tendon, which passes along the inner side of the popliteal space, resting on the semimembranosus, and curves forwards to be inserted in an expanded form into the upper part of the tibia at its inner side. There the tendon is on the same plane, but below that of the gracilis, both being under cover of the sartorius. A narrow oblique tendinous intersection traverses the muscle about the middle.

The *semimembranosus* muscle arises from the tuberosity of the ischium, above and to the outside of the origin of the biceps and semitendinosus, by a strong flattened tendon, two or three inches long, which as it descends in front of the common tendon of those two muscles, passes to their inner side. It terminates inferiorly in a thick tendon, which is inserted in three parts: the principal part turns forwards and is inserted into a well marked groove on the inner tuberosity of the tibia, beneath the internal lateral ligament of the knee-joint, some of its fibres joining that ligament; a second part, passing downwards and outwards, expands in the aponeurosis over the popliteus muscle; and the remaining fibres are directed upwards and outwards, and blend with the posterior ligament of the knee-joint, of which they may be said to form a considerable portion. The muscle consists of numerous short fibres extending obliquely between two aponeurotic expansions, which are continued upwards and downwards on the opposite sides of the muscle for three fourths of its length from the superior and inferior tendons.

The inferior tendon of the semimembranosus muscle is separated from the tendon of the inner head of the gastrocnemius by a large bursa. The muscle rests on the adductor magnus.

The hamstring muscles descend in contact with one another, being bound down by the fascia lata; but inferiorly they diverge, the biceps passing to the outside, and the semimembranosus and semitendinosus to the inner side of the knee, forming the superior borders of a diamond-shaped hollow at the back of the knee—the popliteal space. The great sciatic nerve is concealed by them while they are in contact, and its principal division, the internal popliteal, lies in contact with the semimembranosus muscle in the popliteal space.

ILIAC REGION.

The *ilio-psoas* muscle, the great flexor of the hip-joint, is divisible into two parts, a broad outer part, the iliacus, and an elongated inner part, the psoas magnus, which are inserted together into the small trochanter.

The *iliacus* muscle arises from the iliac fossa of the innominate bone, and from the anterior border of the same, likewise from the base of the sacrum, the ilio-lumbar ligament, and the capsule of the hip-joint. Its fibres converging, as they pass downwards and inwards, are inserted for the most part into a tendon continuous with the psoas muscle; while some are prolonged to a special triangular impression on the upper part of the femur, in front of and below the small trochanter.

The *psoas magnus* arises from the upper and lower lateral parts of the bodies of the last dorsal and of all the lumbar vertebræ, from the interposed fibro-cartilages, and from the anterior surface and lower margin of the transverse processes of the lumbar vertebræ near their bases. It forms a thick elongated muscle, and is inserted into the small trochanter of the femur by means of a tendon, which is placed at first within the substance of the muscle, and afterwards at its outer side, receiving in this manner the fibres of the iliacus as well as those of the psoas.

Fig. 209.

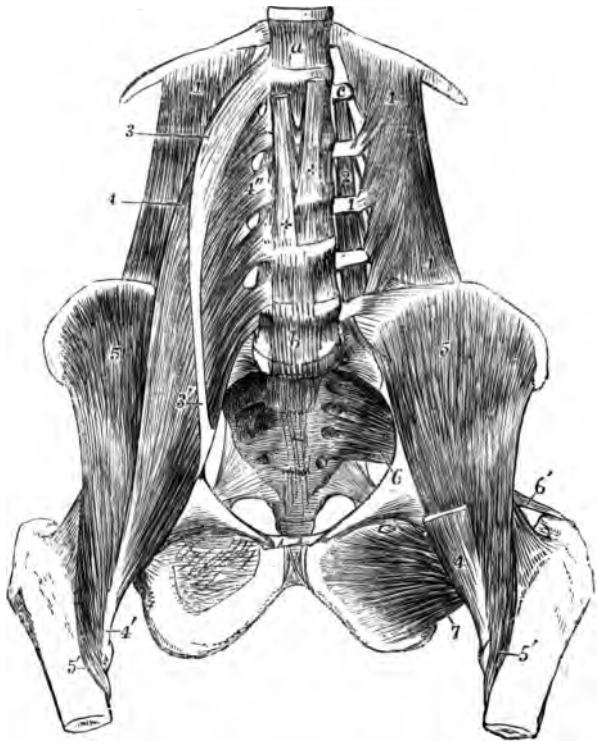


Fig. 209.—Deep Dissection of the Muscles of the Abdomen and Pelvis. ¼

a, twelfth dorsal vertebra; *b*, fifth lumbar vertebra; *c*, transverse process of the first lumbar vertebra; 1, quadratus lumborum muscle; on the left side, its fibres of origin from the transverse processes of the lumbar vertebræ are shown by the removal of the psoas muscles; 2, placed upon one of the intertransversales muscles of the left side; 3, marks the upper part of the psoas parvus, drawn somewhat to the outer side; 3′, the insertion of its tendon into the brim of the pelvis; 4, points to the upper part of the psoas magnus; 4″, one of the origins of the muscle; 4′, the insertion of the muscle into the lesser trochanter of the femur; 5, iliacus internus, shown fully on the left side by the removal of the psoas muscles; 5′, insertion of the iliacus muscle into a line below the trochanter minor; 6, pyriformis muscle of the left side rising within the pelvis from the sacrum; 6′, insertion of its tendon into the summit of the great trochanter; 7, the obturator externus seen from before on the left side; + +, the right and left tendinous pillars of the diaphragm on the front of the upper lumbar vertebræ.

The connection of the psoas with the bodies of the bones is effected by means of five distinct parts, each of which is attached to the upper and lower margins of two vertebræ and the interposed fibro-cartilage; the highest to the neighbouring margins of the last dorsal vertebra and the first lumbar, and the lowest to the edges of the fourth and fifth lumbar vertebræ with the intervertebral substance. These attachments are connected by thin tendinous arches, extending over the middle of each vertebra, covering the lumbar vessels and communicating branches of the sympathetic nerve, and giving origin to other muscular fibres. The psoas muscle, at its superior extremity, passes behind the diaphragm, below the arch of the ligamentum arcuatum internum. Resting on its inner border, along the margin of the pelvis, is the external iliac artery, and deeply in the substance of the muscle is the lumbar plexus of nerves. The ilio-inguinal and external cutaneous nerves cross the iliacus muscle, and the anterior crural nerve descends on the tendon of the psoas. The iliac fascia extends over the surface of the whole ilio-psoas muscle in the abdomen. The muscle emerges from the abdomen beneath Poupart's ligament, and turning over the brim of the pelvis rests on the capsule of the hip-joint, on which it glides by means of a large synovial bursa, which occasionally communicates with the interior of the joint; its outer margin is in contact with the rectus muscle, and its inner margin is separated from the pectineus by the internal circumflex artery.

The *psoas parvus*, an occasional muscle, placed on the surface of the psoas magnus, arises from the bodies of the last dorsal and first lumbar vertebræ, and from the fibro-cartilage between them, and soon ends in a flat tendon, which passes along the front and the inner side of the psoas magnus, to be inserted into the ilio-pectineal line and eminence.

This muscle, although it is well developed and constant in animals, is most frequently absent in the human subject. It was found in only one of twenty bodies examined by Theile with special reference to its existence. When present, it is liable to many changes in the place of origin; thus, it may be connected only with the first lumbar vertebra, or with the second and the intervertebral substance above it, and it has been observed to commence by two parts or heads separated by an interval.

ANTERIOR FEMORAL REGION.

The *tensor vaginæ femoris*, or ilio-aponeurotic muscle of the thigh, arises by muscular and tendinous fibres from the external surface of the iliac crest close to its fore-part, and from part of the notch between the two anterior iliac spines, external to the attachment of the sartorius; and passing downwards and a little outwards it is inserted between two laminæ of the fascia lata, about three inches below the great trochanter of the femur. The outer of these laminæ is continued upwards on the muscle in its whole extent, being part of the general investment of the limb, the deeper is connected above with the origin of the rectus muscle, and with the fibres attaching the gluteus minimus to the hip-joint. The part of the fascia, made tense by the action of the muscle, forms a strong tendinous band, which descends to the outer and back part of the knee-joint.

The *sartorius* is very long, narrow, and ribbon-shaped, and presents the longest fibres of all the muscles in the body: it arises by a short tendon from the anterior superior spinous process of the ilium, and from a small part of the anterior margin of that bone immediately below, and, passing downwards and inwards across the front of the thigh, is inserted by an expanded aponeurosis into the upper and inner side of the tibia, near to the tubercle, and for about an inch below it.

In this long course the muscle is directed over the anterior part of the thigh, obliquely inwards in the upper third, and vertically at the inner aspect of the limb

as far as the knee; below this it turns obliquely forwards to its place of attachment. The tendon of insertion, broad and expanded, covers the tendons of the gracilis and semitendinosus (a synovial bursa being interposed), and gives off one expansion which strengthens the capsule of the knee-joint by becoming incorporated with it, and another which blends with the fascia of the leg.

Fig. 210.

Fig. 210.—Superficial Muscles of the Front of the Thigh. ⅛

a, anterior part of the crest of the ilium; *b*, symphysis pubis; *c*, patella; *d*, is below the anterior tuberosity of the tibia; 1, points to the insertion of the external oblique muscle into the iliac crest; 2, its aponeurosis at the linea semilunaris; 3, the external abdominal ring; 4, part of the gluteus medius; 5, tensor vaginæ femoris at the place of its insertion into a portion of the fascia lata, which has been removed between 5 and 5′, which latter part is seen descending to be attached to the tibia and fibula; 6, the sartorius; 6′, the insertion of the sartorius; 7, psoas and iliacus conjoined; 8, pectineus; 9, adductor longus; 10, gracilis; 11, part of the adductor magnus; 12, vastus externus; 13, rectus femoris; 14, vastus internus; 15, small part of the biceps flexor cruris.

The sartorius is covered only by the fascia lata and the integument. It passes over the iliacus and rectus femoris muscles, the femoral vessels, the pectineus, the adductor longus, adductor magnus, vastus internus, gracilis, and semitendinosus muscles. The inner border of this muscle and the most projecting part of the adductor longus form the sides, and Poupart's ligament forms the base of a triangular space in the upper third of the thigh, through the middle of which the femoral artery passes. This frequently receives the name of Scarpa's triangle.

The *quadriceps extensor cruris*, the extensor muscle of the knee, is divisible into four parts, one of which, the rectus femoris, descends from the hip bone and remains distinct, while the other three, distinguished one from the other only by the arrangement of their fibres, cover the whole of the anterior and lateral surfaces of the thigh bone, from which they arise.

a. The *rectus femoris*, extended in a straight line from the pelvis to the patella, arises by two tendons, one of which is attached to the anterior inferior spinous process of the ilium, and the other, united to the first within an inch of that point, is attached horizontally in the groove above the upper part of the brim of the acetabulum. From the prolongation of the tendon so formed the muscular fibres arise pennately, and turning outwards and

backwards as they descend, are inserted in a similar manner into the tendon below, the superior tendon being prolonged on the anterior, the inferior tendon on the posterior surface of the muscle. The inferior tendon forms a broad band inserted into the upper surface of the patella.

Fig. 211.—Deep Muscles of the Right Thigh in front. ½

Fig. 211.

a, anterior superior, and *b*, anterior inferior spinous process of the ilium; *c*, outer and upper part of the great trochanter; *d*, symphysis pubis; *e*, patella; *f*, inner side of the knee-joint and internal lateral ligament; *g*, head of the fibula and outer side of the knee-joint; 1, front of the gluteus medius; 2, front of the gluteus minimus, separate in this case from the medius; 3, tendon of the rectus, dividing above into its two portions, one proceeding from the inferior spine of the ilium, the other passing back over the upper border of the acetabulum; 4, on the lower part of the anterior inter-trochanteric line and at the lower end of the ilio-femoral part of the capsular ligament, points by a line to the cut tendon of insertion of the ilio-psoas muscle; 5, part of the obturator externus and quadratus femoris; 6, pectineus; 7, part of the adductor brevis; 8, adductor magnus; 9, vastus internus; 10, crureus; 11, vastus externus; 12, tendon of the rectus; 13, lower part of the slip of the fascia lata by which the tensor vaginæ femoris is inserted into the tibia and fibula.

Superiorly this muscle is overlaid by the tensor vaginæ femoris, iliacus, and sartorius muscles; further down it is covered only by fascia. The acetabular tendon lies beneath the gluteus minimus.

b. The *vastus externus* arises by an extensive aponeurosis attached to the base of the great trochanter in front, and to a ridge on its outer side, also to the line extending from that process to the linea aspera, and to the outer border of the linea aspera itself; the aponeurosis is prolonged on the surface of the muscle and gives origin to numerous muscular fibres: further it arises along the line which passes from the linea aspera to the external condyle in its upper two-thirds, by means of muscular fibres attached to the intermuscular septum lying between it and the short head of the biceps. The superior fibres descend perpendicularly, the lowest are nearly horizontal, and the muscle, forming an expanded sheet applied to the surface of the crureus, is inserted by a broad flat tendon into the tendon of the rectus muscle, the patella, and the fascia lata on the front and side of the knee-joint.

c, d. The *vastus internus* and *crureus* consist of different sets of fibres, which are very closely united. The *vastus internus* arises from a line which descends upon the femur at some distance in front of the small trochanter, and which unites the anterior inter-trochanteric line to the inner line diverging from the linea aspera; from the lower half of that inner line, and from the inner lip of the linea aspera; as well as from the fibrous partition attached to the line extended between the linea aspera and the inner condyle in connection with the tendon of the adductor magnus. From this extensive origin, and likewise from the inner surface of the bone, the fibres proceed downwards and forwards, and terminate on the inner surface of the patella and knee-joint in a manner similar to those of the vastus externus. The *crureus* arises on the anterior and outer surfaces of the femur, reaching from the line between the trochanters to within a few inches of the patella, and outwards to the vastus externus. Its fibres are vertical, and are overlaid inferiorly by an aponeurosis; and the muscle is inserted by tendon and fleshy fibres into the upper border and sides of the patella, being inseparably blended with the insertions of the other parts of the quadriceps extensor.

The *subcrureus* is a small band of muscular fibres, which extends from the lower part of the anterior surface of the femur to the upper part of the synovial membrane of the knee-joint, on which it ends in scattered fibres.

This little muscle is placed beneath the crureus muscle, and in some cases it is united with that muscular mass. It is not unfrequently double, or consists of two separate bundles.

INTERNAL FEMORAL REGION.

(*Adductor Muscles.*)

The *gracilis* or *adductor gracilis* muscle, long and slender, arises by a thin aponeurosis from the inner margin of the pubic bone, along the lower half of the symphysis and the upper part of the pubic arch. The lower tendon, which is at first round, is inserted by a flattened and expanded portion into the inner side of the tibia, on the same plane with, but higher than the semitendinosus, and under the expanded tendon of the sartorius.

This slender muscle is covered by the fascia lata, except in a small part inferiorly, where it is overlapped by the sartorius; the deep surface rests against the adductor brevis, adductor magnus, semimembranosus, and the knee-joint with the internal lateral ligament. A bursa separates it from that ligament.

The *pectineus* muscle, flat and nearly quadrangular, arises from the pectineal line, and from the surface of bone in front of it, between the iliopectineal eminence and the pubic spine. Inclining outwards and backwards as it descends, it is inserted by a flat tendon into the femur behind the small trochanter, and into the upper part of the line which connects the linea aspera of the femur with that prominence.

The pectineus is in contact, by its anterior surface, with the fascia lata and the femoral vessels; by the posterior surface, with the obturator vessels and nerve, and the external obturator and adductor brevis muscles. By the outer border it touches the psoas magnus; by the inner border, the adductor longus.

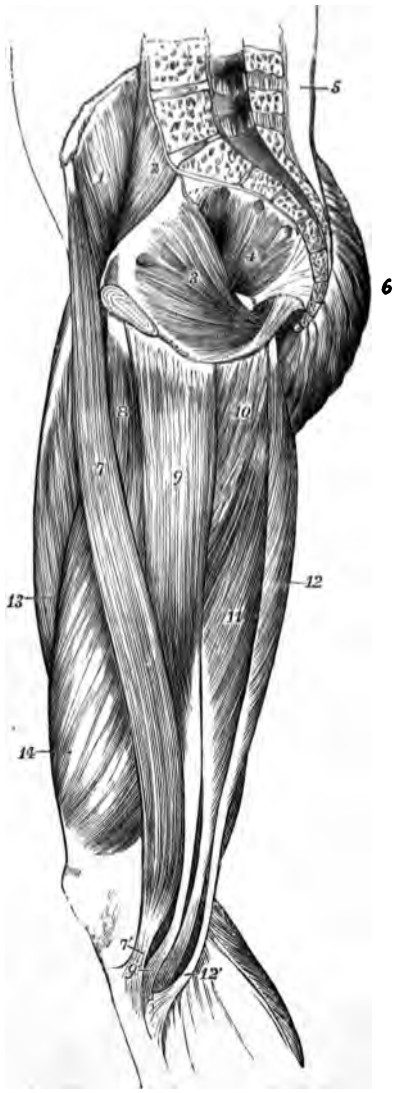
The *adductor longus*, a flat triangular muscle, internal to the pectineus, and lying in the same plane, arises by a short tendon from the body of the pubes below the crest and near the angle, and is inserted into the inner

margin of the linea aspera in its whole length, between the vastus internus and the adductor magnus.

Fig. 212.—Superficial Muscles of the Inner Side of the Thigh, and Muscles on the Inner Wall of the Pelvis. ½

1, iliacus muscle; 2, part of the psoas magnus muscle; 3, obturator internus, with its fibres converging towards the lesser sciatic foramen; 4, pyriformis, with three heads of origin, and its fibres converging towards the great sciatic foramen; 5, a part of the lumbar aponeurosis covering the erector spinæ muscle; 6, gluteus maximus; 7, sartorius, 7′, its tendon inserted below the tuberosity of the tibia; 8, a part of the adductor longus; 9, gracilis, 9′, its insertion passing below that of the sartorius; 10, part of the adductor magnus; 11, semimembranosus; 12, semitendinosus, 12′, its insertion, and between 9′ and 12′ the tendon of the semimembranosus passing to its insertion in the inner tuberosity of the tibia.

Fig. 212.



This muscle is covered by the fascia lata, the sartorius, and the femoral vessels; the posterior surface rests superiorly on the adductor brevis, and inferiorly on the adductor magnus. Externally it is separated by a small interval from the pectineus, and internally it is in apposition with the gracilis.

The *adductor brevis*, thick above and broad below, arises by a narrow origin, about two inches deep, in contact with that of the gracilis, from the anterior surface of the body, and the descending ramus of the pubes; directed obliquely backwards and outwards it is inserted by a flat tendon into the whole of the oblique line leading from the small trochanter of the femur to the linea aspera, immediately behind the insertion of the pectineus.

The adductor brevis is concealed at its origin by the adductor longus and at its insertion in part by the pectineus; it rests on the adductor magnus, and by its deep surface is in contact superiorly with the obturator externus.

The *adductor magnus* muscle arises from a part of the body of the pubes

external to the lower part of the origin of the adductor brevis, from the rami of the pubes and ischium, and from the tuberosity of the ischium near the pubic arch. The muscular fibres diverge from their origin, somewhat like the ribs of a fan from their central pivot; those from the pubes, shorter than the rest, pass transversely outwards, and are inserted below the linea quadrati into the line prolonged from the linea aspera to the great trochanter; others pass with increasing degrees of obliquity downwards and outwards, to be inserted into the whole length of the linea aspera, and into a part of its internal bifurcation below; finally, some of the fibres descend almost vertically, forming the inner border of the muscle, and terminate in a narrow tendon, which is inserted into the tuberosity of the inner condyle of the femur.

Below the level of the inferior bifurcation of the linea aspera, between the tendinous and fleshy portions of the insertion of the muscle, an interval is left for the transmission of the femoral vessels backwards into the popliteal space, and along the femoral attachment the insertion is interrupted by three or more tendinous arches through which pass the perforating arteries.

This muscle is in contact with the long and short adductors and the vastus internus in front, with the hamstring muscles and gluteus maximus behind, with the gracilis muscle internally, and with the obturator externus and quadratus femoris muscles superiorly.

ACTIONS OF THE MUSCLES OF THE HIP AND THIGH.

The *gluteus maximus* muscle is the chief extensor of the hip-joint. By means of it the bent thigh is brought into a line with the body; but its most important action, and that in connection with which it is so largely developed in the human subject, is to extend the trunk upon the thigh when supported on the ground by the limbs, and in so doing the muscles of both sides act in combination. The upper part of the muscle has an abducting, and the lower part an adducting power upon the limb. Although the full contraction of the glutei maximi is required to bring the body into the erect posture, it is not necessary for its maintenance, that being effected chiefly by the tension of certain ligaments and fasciæ passing over the joints, and the body in that posture being so poised that the centre of gravity of the trunk is placed slightly behind the vertical plane passing through the middle of the hip-joints. The *gluteus medius* and *minimus* are powerful abductors of the thigh, and along with the tensor vaginæ femoris, come principally into action in supporting the body on one limb, which is done to a certain extent in each step in walking. Their anterior fibres draw forwards the great trochanter, and rotate the limb inwards, and the more the thigh is flexed the greater the number of fibres which will exercise this action.

The *tensor vaginæ femoris* is generally held to assist the action of the other muscles by making tense the fascia lata. It likewise aids the preceding muscles in rotating the limb inwards: its action in this respect is exactly opposed by the upper fibres of the gluteus maximus, which fibres, together with the tensor vaginæ femoris, being continued into a band of the fascia lata descending to the outer tuberosity of the tibia, must act as supporters of the thigh at the knee-joint, and are considered by Meyer (op. cit. p. 222) to act as extensors of the knee.

The *pyriformis*, *obturator internus* and *gemelli* muscles support the hip-joint posteriorly, and rotate the limb outwards. Their greatest contraction is admitted when the thigh is extended and the toes are directed outwards; they may be supposed therefore to give stability to the erect posture.

The *quadratus femoris* is partly an adductor and partly a rotator outwards. This muscle, as well as the pyriformis, obturator internus and gemelli, and obturator externus, come to be extensors when the thigh is strongly flexed.

The *obturator externus* has its origin and insertion most approximated when the thigh is flexed, adducted, and rotated outwards, as is the case in the uppermost of the two limbs when we cross the knees in sitting. It supports the hip-joint posteriorly and inferiorly, and is a rotator outwards.

The *ilio-psoas* muscle, the flexor of the hip-joint, flexes the thigh on the body, or the body on the thigh, according as either of these is the most fixed.

The *pectineus* is partly a flexor and partly an adductor.

The *adductores magnus, longus* and *brevis* adduct the thigh, and along with their opponents the gluteus medius and minimus, and with the gluteus maximus, balance the body on the femur in walking.

The *adductor* muscles and *ilio-psoas*, together with the pectineus, being all inserted at the back part of the femur, tend to rotate the thigh outwards at the same time that they produce their adducting and flexing actions. The advantage of this preponderance of rotators outwards over rotators inwards becomes apparent by reference to the movements which take place in walking. When a step is taken, the pelvis is drawn forwards on that side on which the foot has been advanced, which involves a considerable rotation of the pelvis outwards at the other hip-joint, by the action of the muscles of the opposite limb.

The *quadriceps extensor femoris* extends the knee-joint, but, as already mentioned with regard to the gluteus maximus, its action is not requisite for the maintenance of the erect attitude, the knee-joint remaining in complete extension without muscular aid while the foot is firmly planted on the ground. This may be tested by the fact that the patella of a person standing with the knee extended will be found to lie quite loosely, but will become at once fixed when it is attempted to lift the foot.

The rectus femoris, sartorius, gracilis, semitendinosus, semimembranosus, and long head of the biceps act on both the hip and knee-joints.

The *sartorius* produces the flexion of the hip and knee-joints, accompanied by abduction, which occurs in the posture assumed by the tailor in sitting, and the muscle derives its name from this circumstance.

The *rectus femoris* flexes the hip and extends the knee; it acts wholly from its anterior head of origin when the thigh is fully extended, and the posterior head is alone tense when the thigh is bent.

The *hamstring muscles* extend the hip and flex the knee. It is to be observed, however, that in the ordinary movements of the body, the hip and knee-joints are flexed and extended together, and that therefore the joint on which those long muscles act must be determined by the other muscles which pass over either of those joints separately.

The *gracilis* acts as an adductor on the hip-joint. The gracilis, semitendinosus, and sartorius muscles form the group of rotators inwards at the knee-joint; they act along with the popliteus in this respect to greatest advantage in the flexed state of the knee; but they likewise favour the commencement of flexion by undoing that rotation inwards of the femoral condyles on the tibia by which extension of the knee is completed.

The *short head* of the *biceps* is the only flexor of the knee, which passes over that joint alone. The whole of this muscle produces external rotation of the leg.

The *subcrureus* in extension of the knee-joint probably raises the upper part of the synovial membrane, and prevents it from being pressed between the patella and femur.

MUSCLES OF THE LEG AND FOOT.

ANTERIOR REGION.

Between the tibia and fibula, on the front of the leg, are placed four muscles—the tibialis anticus, extensor proprius pollicis, extensor longus digitorum, and peroneus tertius; and on the dorsum of the foot one muscle only arises,—the extensor brevis digitorum.

The *tibialis anticus* arises from the external tuberosity of the tibia, and about two-thirds of the outer surface of that bone; from a small portion of the adjoining interosseous ligament; from the strong fascia of the leg; and from an aponeurotic septum placed between it and the extensor longus digitorum. The tendon in which all the muscular fibres terminate before

it reaches the bend of the ankle, glides in a synovial sheath beneath the anterior annular ligament, and is inserted into the inner and lower part of the internal cuneiform and the contiguous extremity of the first metatarsal bone, dividing slightly into two slips as it descends.

Fig. 213.

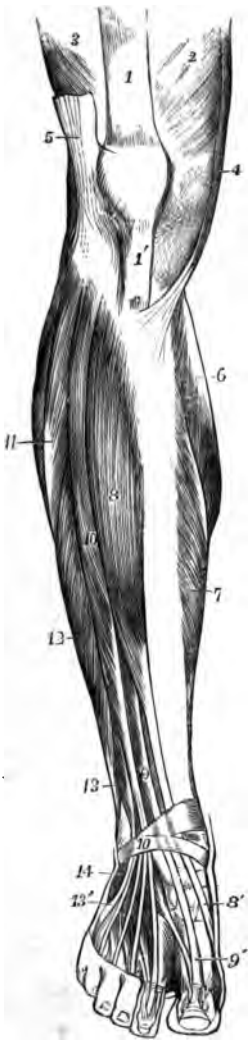


Fig. 213.—Muscles of the Lower Leg and Foot from before. ½

1, tendon of the rectus femoris; 1′, ligamentum patellæ; 2, the lower part of the vastus internus; 3, lower part of the vastus externus; 4, lower part of the sartorius; 5, small portion of the fascia lata cut near the place of its insertion at the knee; 6, inner head of the gastrocnemius; 7, inner part of the soleus; 8, tibialis anticus; 8′, its tendon near the insertion; 9, part of the extensor longus pollicis; 9′, its tendon; 10, extensor communis digitorum longus; 10′, placed on the anterior annular ligament over the place of passage of the four tendons of the extensor communis; 11, peroneus longus; 12, peroneus brevis; 13, peroneus tertius; 13′, tendon of the peroneus tertius at its insertion; 14, origin of the extensor communis digitorum brevis, the first head of which is seen passing to the great toe near the line from 9′.

The *extensor proprius pollicis*, placed between the tibialis anticus and the extensor longus digitorum, arises from the middle three-fifths of the anterior narrow part of the inner surface of the fibula, and from the contiguous portion of the interosseous ligament for the same extent. The fleshy fibres run obliquely forwards into a tendon placed at the anterior border of the muscle; and the tendon, after passing beneath the upper, and through the lower portion of the annular ligament in a distinct compartment, and along the dorsum of the foot, is inserted into the base of the terminal phalanx of the great toe. A delicate expansion given off from the tendon on each side spreads over the joint between the metatarsal bone and the first phalanx.

This muscle is partly concealed by those between which it is placed. It lies external to the anterior tibial artery in the leg, but crosses in front of that vessel at the bend of the ankle, and is internal to it on the foot.

The *extensor longus digitorum pedis*, is situated in contact with the tibialis anticus above, and between the extensor proprius pollicis and peroneus tertius below; it arises from the external tuberosity of the tibia; from the head and the anterior narrowed part of the inner surface of the fibula in front of the interosseous membrane, for about three-fourths of its length; from a small part of the interosseous ligament at its upper part; also from the aponeurotic septa intervening between it and the muscles on

each side, and from the fascia of the leg. The fleshy fibres from this extensive origin pass obliquely into a tendon placed on the anterior part of the muscle. This subsequently divides into four slips, which descend through the lower part of the annular ligament, in the same sheath as the peroneus tertius, and on the dorsum of the foot pass respectively to the four outer toes. Not unfrequently the slip belonging to the fifth toe is separated with that of the peroneus tertius from the rest considerably higher up. The three inner tendons are each joined at the outer side, on the first phalanx, by a tendon from the extensor brevis digitorum: all the four tendons are continued into expansions, which are joined on the first phalanx by tendinous processes from the lumbricales and interossei muscles, and have their middle fibres inserted into the second phalanx; while their lateral parts unite together and are inserted on the third, in a manner exactly similar to the arrangement of the extensor tendons on the fingers.

Fig. 214.

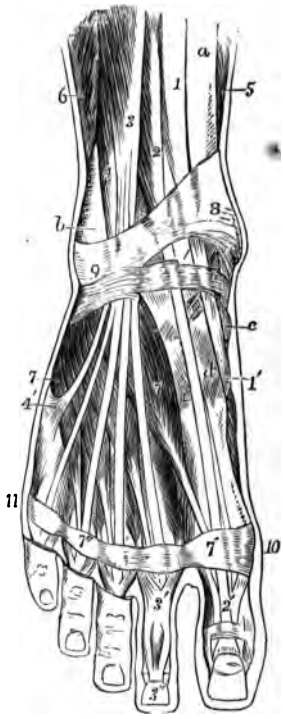


Fig. 214.—Superficial Muscles and Tendons on the Dorsum of the Foot and Lower Part of the Leg anteriorly (after Bourgery). ⅓

a, lower part of the tibia; *b*, lower part of the fibula above the malleolus externus; *c*, inner side of the scaphoid bone; *d*, internal cuneiform bone; 1, lower part of the tibialis anticus muscle; 1′, its tendon descending in the groove of the internal cuneiform bone; 2, extensor longus pollicis; 2′, its expansion on the dorsum of the great toe; 3, extensor communis digitorum dividing into its four tendons for the toes; 3′, the expansion, and 3″, the final insertion of the same upon the second toe; 4, peroneus tertius; 4′, its expanded insertion on the base of the fifth metatarsal bone; 5, small part of the fibres of the soleus on the inner side of the tibia; 6, small part of the peroneus brevis; 7, extensor brevis digitorum, seen below the tendons of the extensor longus and peroneus tertius; 7′, 7″, on a band of aponeurosis crossing the toes, the first and fourth tendons of the extensor brevis muscle passing to join those of the long extensor; 8, 9, anterior annular ligament, chiefly in its lower part, or ligamentum cruciatum; between 8 and *c*, the inner and lower band enclosing the extensor longus pollicis and tibialis anticus; below 9, the outer part of the same enclosing the tendons of the extensor communis and peroneus tertius; 10, 11, dorsal transverse band of the aponeurosis of the foot, uniting the heads of the metatarsal bones.

The *peroneus tertius* arises, in continuity with the lower part of the extensor longus digitorum, from the lower fourth of the inner surface of the fibula, from the lower part of the interosseous membrane, and from an aponeurosis which connects it on the outer side with the peroneus brevis. The muscular fibres end in a tendon, which, after passing through the annular ligament with the long extensor of the toes, is inserted into the upper surface of the base of the fifth metatarsal bone, and likewise in some instances into the fourth.

There is often scarcely any line of demarcation between the two preceding muscles. The peroneus tertius is sometimes as large as the extensor longus digitorum, sometimes its tendon is as large as those of that muscle combined; it has been observed to terminate on the fourth metatarsal bone; and it is sometimes altogether wanting.

Five tendons are ascribed to the extensor longus digitorum by Cowper (Myot. Reform., c. 36, p. 111), the peroneus tertius having been considered by him as part of that muscle, a view which is in some degree warranted by the form which it usually presents.

The *extensor brevis digitorum pedis* arises from the outer surface of the os calcis in front of the groove for the peroneus brevis muscle, and from the lower band of the anterior annular ligament. It divides into four tapering slips each of which terminates in a tendon; the first or most internal of these, sometimes reckoned as a distinct muscle, is inserted separately into the dorsal surface of the first phalanx of the great toe near its tarsal extremity; and the other three become severally united to the outer border of the extensor tendons proceeding to the three next toes.

EXTERNAL REGION.

The *peroneus longus* arises from the head of the fibula, and from more than the two upper thirds of the external surface of that bone; from the fascia of the leg; and from aponeuroses interposed between it and the contiguous muscles, viz., the extensor communis digitorum on one side, and the soleus and flexor longus pollicis on the other. It ends above the ankle in a tendon, which passes downwards behind that of the peroneus brevis in the hollow behind the external malleolus, and inclining forwards, turns over the outer margin of the foot, and enters the excavation on the lower surface of the cuboid bone, and changing its direction, proceeds inwards and forwards to be inserted into the lower part of the internal cuneiform and the tarsal end of the first metatarsal bone: an offset is continued from it to the base of the second metatarsal bone. In this course the tendon of the peroneus longus muscle, lying parallel with that of the peroneus brevis, is invested along with it by a synovial membrane, and bound down by a fibrous band extended from the end of the fibula to the calcaneum; on the outer side of the foot it separates from the peroneus brevis, and in the sole of the foot the peroneus longus lies in a synovial sheath formed by fibres of the ligamentum longum plantæ.

The *peroneus brevis* arises from the two lower thirds of the external surface of the fibula, internal to the peroneus longus, and from the intermuscular septa which dip down in front between it and the extensor longus digitorum and peroneus tertius, and behind between it and the flexor longus pollicis. The fibres are directed to a tendon on their outer surface, which becoming free at the level of the external malleolus, passes behind that process, sheathed in the same synovial membrane as the tendon of the peroneus longus, and inclining forwards is inserted into the projection at the base of the fifth metatarsal bone, having traversed a separate sheath on the calcaneum, above that for the tendon of the peroneus longus, but lined by an offset of the same synovial membrane.

POSTERIOR REGION.

The muscles at the back of the leg consist of a superficial group inserted into the extremity of the calcaneum, and a deeper group covered in by a deep fascia and descending to the sole.

The *superficial group* consists of three muscles; two of them, placed one on the surface of the other, are of large size, the *gastrocnemius* and *soleus* (extensor tarsi suralis vel extensor magnus,—Douglas; musculus suræ,

Sœmmerring), form the bulk of the calf of the leg, and are inserted into the heel by a common tendon—the tendo Achillis; the third, a small muscle, the *plantaris*, descends between the other two.

The *gastrocnemius* muscle arises by two thick tendinous heads from the condyles of the femur, and ends below in the tendo Achillis. The

Fig. 215.—Superficial Muscles of the Lower Leg, seen from behind (after Bourgery). ½

1, lower part of the vastus externus; 2, tendon of the biceps flexor cruris, passing to its insertion in the fibula; 3, lower part and tendon of the semitendinosus; 4, lower part of the semimembranosus: its tendon is seen between 3 and 5 passing to its insertion in the tibia; 5, gracilis; 6, small part of the sartorius; 7, outer, and 8, inner head of the gastrocnemius on the tendinous part of the calf of the leg; 9, placed in the popliteal space, points to the muscular part of the plantaris; 9′, its thin tendon inside the tendo Achillis; 10, the fibres of the soleus descending to the flat tendon, which, joining with that of the gastrocnemius, forms + + the tendo Achillis; 11, lower part and tendon of the peroneus longus; 12, lower fibres of the peroneus brevis, both passing behind the malleolus externus below; 13, lower part of the flexor longus digitorum; 14, small part of the tendon of the tibialis posticus, which, along with 13, descends behind the malleolus internus; 15, is placed near the lower part of the fibula, and points to the lower fibres of the flexor longus pollicis, the tendon of which is seen descending over the tibia at 15′.

Fig. 215.

outer tendon of origin is attached in an oblique line to a depression on the outer side of the external condyle, above the groove for the popliteus muscle. The inner tendon is attached in a horizontal line to an impression above the back part of the internal condyle, and along with it are fleshy fibres connected for a short distance with the ridge running to the linea aspera. The muscular fibres descending from the two heads remain separated by a vertical groove on the surface, but those next the middle meet at an angle on a tendinous structure below. The fibres of the superior tendons spread out upon the surface of the muscle; the inferior tendon lies on the deep surface of the muscular mass, and is continued upwards in a thin aponeurosis with parallel fibres, which glide against the soleus: between the superficial tendon of each head and the deep common tendon, the greater number of the muscular fibres run obliquely downwards and forwards. The lower edge of each muscular part presents a convexity downwards; the inner descending furthest. A synovial membrane, usually communicating with the knee-joint, lies beneath the inner head of origin, and separates it from

the tendon of the semimembranosus muscle. A sesamoid fibro-cartilage is sometimes met with over the outer condyle of the femur, and occasionally over the inner: it is rarely ossified.

The heads of the gastrocnemius muscle form the inferior boundaries of the popliteal space, and are placed between the hamstring muscles: the peroneal nerve is lodged between the external head and the biceps. The gastrocnemius conceals the popliteus muscle, with the popliteal vessels and internal popliteal nerve lying on its surface; the plantaris and soleus are also covered by it. The short saphenous vein is placed on its surface, in the interval between its two parts.

Fig. 216.

Fig. 216.—SUPERFICIAL MUSCLES OF THE LEG, SEEN FROM THE INNER SIDE (after Bourgery). ½

1, part of the vastus internus; 2, sartorius; 2′, its flat tendon, spreading on the inner upper part of the tibia; 3, gracilis; 4, semitendinosus; 4′, its insertion; and between 2′ and 4′, that of the gracilis; 5, semimembranosus; 6, inner head of the gastrocnemius; 7, soleus; 8, 8′, placed upon the tendo Achillis, point to the small tendon of the plantaris descending on the inner side; 9, small part of the tendon of the tibialis posticus; 10, flexor communis digitorum; 11, points to a portion of the flexor longus pollicis, sunk in shadow; 12, a narrow part of the tibialis anticus; 12′, on the internal cuneiform bone, above the divided tendon of insertion of the tibialis anticus; 13, abductor pollicis; there are also shown in this part of the figure the connection of the abductor posteriorly with the internal annular ligament and os calcis, and the manner in which the internal annular ligament forms a retinaculum for the tendons of the muscles of the leg as they descend.

The *soleus* muscle arises externally from the posterior part of the head of the fibula, and from the surface beneath it for a third of the length of the bone; internally from the oblique line which gives insertion to the popliteus, and from the posterior edge of the tibia about three inches below that line; also in the space intermediate between the tibia and fibula, from a tendinous band extended from one bone to the other over the posterior tibial vessels and nerve. Inferiorly the muscular fibres descend upon the tendo

Achillis considerably further than those of the gastrocnemius. The posterior surface presents a thin covering of longitudinal aponeurotic fibres continued up from the tendon below, and gliding on the similar tendinous surface of the gastrocnemius muscle. On the deep surface the edges of two membranous tendons, the other edges of which look towards the middle line of the muscle, imbedded in its substance, are seen descending from the tibial and fibular origins: the fibres from the deep aspects of those tendons are directed obliquely inwards to a tendinous septum which divides the muscle into lateral halves; while those from their superficial aspects pass with similar obliquity to the flat tendon on the surface of the muscle, the fibres placed at the sides forming the lateral borders and part of the deep surface of the muscle. Thus the soleus is composed entirely of short oblique fibres of from one to two inches in length.

The soleus rests upon the flexor longus pollicis, flexor longus digitorum and tibialis posticus muscles, together with the posterior tibial vessels and nerve.

The *tendo Achillis*, the thickest and strongest tendon in the body, is formed by the union of the flat tendon of the gastrocnemius with the thicker and more rounded tendon of the soleus. It is from three to four inches long below the point where the muscular fibres of the soleus cease to be attached to it. It is inserted inferiorly into the back part of the tuberosity of the os calcis. Between the upper part of the tuberosity of the os calcis and the tendon a synovial bursa is interposed.

The gastrocnemius is, in some cases, joined by a bundle of muscular fibres, which arises separately from the femur above one of the condyles. This bundle has been observed passing between the popliteal artery and vein (R. Quain, op. cit. plate 80, figs. 4 and 5). To the soleus an accessory portion is occasionally added at its lower and inner part; this usually ends on the inner side of the tendo Achillis, but it sometimes forms a tendon, attached separately to the os calcis.

The *plantaris* arises from the femur immediately above the external condyle, and from the posterior ligament of the knee-joint, where this is covered by the corresponding head of the gastrocnemius; its muscular part is from three to four inches in length, and terminates in a long delicate tendon, which inclines inwards between the gastrocnemius and soleus, and running along the inner border of the tendo Achillis is inserted conjointly with it into the posterior part of the calcaneum.

The designation by which this little muscle is known was assigned to it when the tendon was believed to terminate in the plantar fascia, as the palmaris longus does in the fascia of the hand. It was so described by Galen; and, though the real manner of termination was correctly pointed out by Vesalius (Oper. 1, 2, p. 419), the error was continued through many succeeding works, and is to be found even in Cowper's "Myotomia Reformata" (p. 105).

The plantaris varies in its mode of termination; it is sometimes enclosed in the lower part of the tendo Achillis; and, in other cases, it ends in the internal annular ligament, which binds down the tendons and vessels behind the inner malleolus.

The *deep group* of posterior muscles of the leg is in close contact with the bones; it consists of the popliteus, flexor longus digitorum, flexor longus pollicis and tibialis posticus.

The *popliteus*, an oblique muscle placed below the knee, arises by a thick tendon, about an inch in length, from the fore part of the popliteal groove on the outer side of the external condyle of the femur, within the external lateral ligament and capsule of the knee-joint; it is in contact with the

external semilunar cartilage, and receives additional fibres from the posterior ligament of the joint. The muscular fibres diverge as they pass downwards,

Fig. 217.

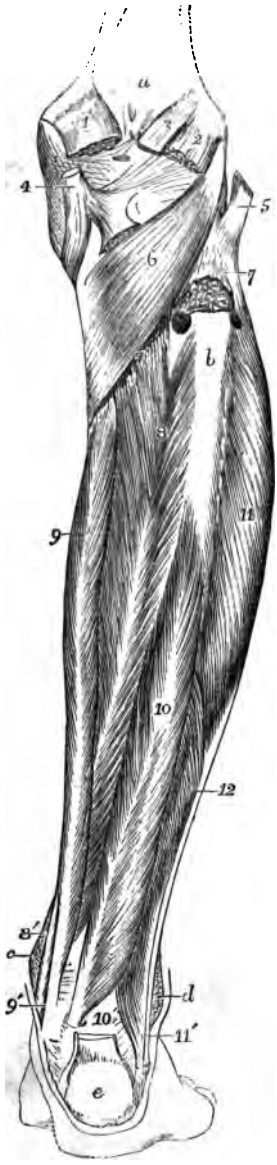


Fig. 217.—Deep Posterior Muscles of the Leg. ¼

a, popliteal surface of the femur; *b*, bare surface of the upper fourth of the fibula, from which the soleus muscle has been removed; *c*, malleolus internus; *d*, malleolus externus; *e*, tuberosity of the os calcis, with the tendo Achillis inserted into it, and the plantaris on its inner side; 1, inner head of the gastrocnemius cut short at its origin; 2, outer head; 3, plantaris; 4, tendon of the semimembranosus muscle near its insertion, seen spreading in three portions, viz., to the inside of the tibia, towards the popliteal fascia, and towards the ligamentum posticum; 5, tendon of the biceps inserted into the head of the fibula; 6, popliteus muscle; 7, upper part of the origin of the soleus from the fibula, cut short; 7′, line of its tibial origin; between these figures is seen the perforation in the upper part of the interosseous membrane; 8, tibialis posticus; 8′, its tendon, passing between the flexor digitorum communis and the tibia; 9, flexor digitorum communis; 9′, its tendon, with that of the tibialis posticus, passing behind the malleolus internus; 10, flexor longus pollicis; 10′, placed beside its tendon, where it passes over the tibia and astragalus; 11, peroneus longus; 11′, its tendon behind that of the peroneus brevis, passing down behind the malleolus externus; 12, peroneus brevis.

and are inserted into all that triangular surface of the tibia which is above the posterior oblique line.

The tendon of the popliteus muscle occupies the groove on the femur in flexion only.

The popliteus is bound down by an aponeurosis, principally derived from the tendon of the semimembranosus muscle. The popliteal vessels and internal popliteal nerve lie upon its posterior surface, and it is covered by the gastrocnemius muscle.

The three remaining muscles of this group are bound down together by a deep fascia, which extends between the tibia and fibula, and separates them from the soleus.

The *flexor longus digitorum pedis*, or *flexor perforans*, arises from the posterior surface of the tibia, in the space below the oblique line, and as far down as within three inches of the inner ankle; it likewise arises by aponeurotic fibres connected with the flexor longus pollicis, which pass over the surface of the tibialis posticus. The fleshy fibres pass obliquely backwards into a tendon

at the posterior aspect of the muscle. The tendon descends in the groove behind the internal malleolus, superficial to the tibialis posticus, and invested by a distinct fibrous and synovial sheath; it is then directed under the arch of the os calcis, obliquely forwards and outwards, into the sole of the foot, where it crosses below the tendon of the flexor longus pollicis, and is connected with it by a tendinous slip; it then divides into four parts, which pass forwards to be inserted into the terminal phalanges of the four smaller toes. Each digital tendon enters a fibrous sheath on the toe for which it is destined, perforates the corresponding tendon of the flexor brevis digitorum, and is invested with synovial membrane, and connected by vincula accessoria to the phalanges; the whole arrangement being exactly similar to that which has been already described as occurring in the fingers.

The posterior tibial vessels lie upon the surface of the flexor longus digitorum.

Intimately connected with the tendon of the flexor longus digitorum are the flexor accessorius and the lumbricales muscles, which, although they occupy the foot, may be most conveniently described in this place.

The *flexor accessorius* (moles carnea—Sylvius) arises by two heads, the internal and larger of which is fleshy, and is attached to the inner surface of the calcaneum, while the external, flat, narrow and tendinous, is attached to the plantar surface of the calcaneum a little in front of the external tubercle, and to the ligamentum longum plantæ. Those origins united form a muscular mass which is inserted into the external border and upper and lower surfaces of the tendon of the flexor longus digitorum.

Fig. 218.

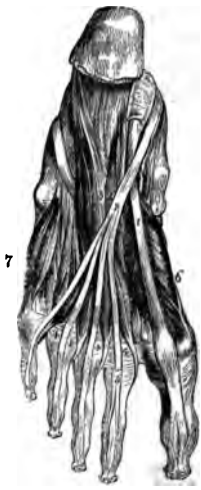


Fig. 218.—Middle Layer of the Plantar Muscles of the Foot, together with the Tendons of the Long Flexors and the Accessorius and Lumbricales Muscles. ¼

1, tendon of the flexor longus pollicis muscle, emerging behind from its sheath below the sustentaculum tali, and passing deeper than, 2, the tendons of the deep common flexor; 3, two heads of the flexor accessorius; 4, the four lumbricales; 5, tendon of the flexor brevis cut short and left on the second toe, seen splitting to allow the passage through it of the tendon of the long flexor; 6, flexor brevis pollicis; 7, flexor brevis minimi digiti; there is also represented on the outer side of the foot the tendon of the peroneus longus winding round the cuboid bone, to pass across the foot in its groove, where it is concealed by the accessorius and other muscles.

The *lumbricales* muscles, four in number, arise from the tendons of the flexor longus digitorum at their point of division, each being, with the exception of the most internal, attached to two tendons, and pass forward to the inner sides of the four outer toes; each muscle ends in a tendon, which is united with the base of the first phalanx, and is inserted into the expansion of the extensor tendon on the dorsum of the toe.

The lumbricales of the foot are less fully developed than those of the hand. They are liable to the same variations.

In the sole of the foot the tendon of the flexor longus digitorum, together with the flexor accessorius and lumbricales, is covered below by the flexor brevis digitorum; the plantar nerves and hinder part of the external plantar artery being placed

between them. This divided tendon, with its additional muscles, conceals the adductor pollicis, the tendon of the flexor longus pollicis, the transversus pedis, the interossei muscles, and the plantar arterial arch.

The *flexor longus pollicis pedis* arises from the two inferior thirds of the posterior surface of the fibula, except for an inch at its lowest part; from the intermuscular septum interposed between it and the peronei; and from the aponeurosis common to it and the flexor longus digitorum, and which covers the tibialis posticus.

The muscular fibres, passing obliquely backwards and downwards, end in a tendon on their posterior surface. This tendon traverses a groove behind the tibia, and another at the back of the astragalus, being bound down to those bones by fibrous and synovial sheaths. Thence passing forwards below the sustentaculum tali, it is connected, in the sole of the foot, by a tendinous slip, with the tendon of the flexor longus digitorum, by which it is crossed, and proceeds in a fibrous sheath over the first phalanx of the great toe to be inserted into the base of the terminal phalanx.

Below the ankle the tendon of this muscle is separated from those of the tibialis posticus and flexor longus digitorum by an interval of more than half an inch, in which are placed the posterior tibial vessels and nerves.

The *tibialis posticus* muscle, placed between the two long flexor muscles, arises from the whole interosseous membrane except for two inches at the lower end, and from the adjacent surfaces of the tibia and fibula, the tibial attachment extending from the superior tibio-fibular articulation to a point at a lower level than that of the flexor longus digitorum, and the attachment to the fibula extending along the three middle fifths of that bone; it also arises from the aponeurosis derived from the adjacent muscles, which covers it. The muscular fibres end in a strong flat tendon, which, passing between the tibia and the long flexor of the toes, turns forwards in a groove beneath the internal malleolus, and is inserted into the tuberosity of the scaphoid bone.

Fig. 219.

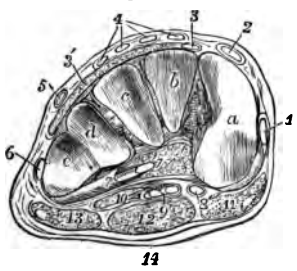


Fig. 219.—Transverse Section of the Right Foot between the Tarsus and Metatarsus, showing the Tendinous and Aponeurotic Structures from the Front. ½

This figure is also designed to show the transverse arch formed by the three cuneiform and the cuboid bones. *a*, articular surface of the internal cuneiform bone for the first metatarsal; *b*, the middle cuneiform; *c*, the external cuneiform; *d* and *e*, the surfaces of the cuboid bone for the fourth and fifth metatarsal bones; between these bones are seen the strong interosseous and plantar ligaments which bind them together; 1, slip of the tendon of the tibialis anticus, which passes on to its insertion in the first metatarsal bone; 2, tendon of the extensor longus pollicis; 3, slip of the extensor brevis digitorum to the great toe; 3', remainder of the extensor brevis digitorum; 4, four slips of the extensor communis digitorum longus; 5, peroneus tertius; 6, peroneus brevis; 7, peroneus longus cut obliquely where it is emerging from the sheath below the cuboid bone; beside 7, the space between the cuneiform bones and the subjacent fasciæ and tendons is occupied by loose fatty tissue; 8, tendon of the flexor longus pollicis; 9, tendon of the flexor communis digitorum longus, with the slip of union from the flexor pollicis; 10, flexor accessorius; 11, fleshy part of the abductor pollicis; 12, flexor brevis digitorum; 13, abductor minimi digiti.

From the insertion, offsets of the tendon are prolonged forwards to all the cuneiform bones, to the os cuboides, and to the bases of the second, third, and fourth metatarsal bones; and one thin process is directed back to the sustentaculum tali. The tendon is covered by a synovial membrane behind the malleolus. Close to its insertion, where it lies against the astragalus, it contains a sesamoid fibro-cartilage, which is occasionally converted into bone.

The tibialis posticus is concealed in great part by the aponeurosis prolonged over it from the muscles on either side. Superiorly it is not covered by these muscles, and supports the posterior tibial and peroneal vessels.

SHORT PLANTAR MUSCLES.

COMMON FLEXOR OF THE TOES.—The *flexor brevis digitorum*, or *flexor perforatus*, arises by a small pointed and tendinous attachment from the inner part of the greater tuberosity of the calcaneum, from the deep surface of the plantar fascia for about two inches forwards, and from the intermuscular septum on each side. The muscle terminates in four slender tendons, inserted into the second phalanx of each of the four outer toes. Each tendon prior to its insertion divides and gives passage between its parts to the tendon of the long flexor, in a manner precisely similar to the arrangement of the tendons of the flexor sublimis and flexor profundus muscles of the hand.

This muscle lies between the abductor pollicis and abductor minimi digiti, and is covered by the plantar fascia, which adheres very closely to the posterior part of its surface, and gives origin there to some of its fibres; it conceals the flexor accessorius, with the tendons of the flexor longus digitorum, the lumbricales, and the plantar vessels and nerves.

Fig. 220.—SUPERFICIAL PLANTAR MUSCLES, AS SEEN ON THE REMOVAL OF THE PLANTAR FASCIA. ½

1, abductor pollicis; 2, flexor brevis digitorum dividing into four slips for the lesser toes: in the second, the sheath is opened so as to show the tendon of the flexor brevis perforated by that of the flexor longus; in the other three toes the transverse and oblique crossing fibres of the sheath are shown; 3, strongest portion of the plantar aponeurosis left upon the surface of the flexor brevis, near the os calcis; 4, abductor minimi digiti: the lumbricales muscles are also in part shown.

Fig. 220.

MUSCLES OF THE GREAT TOE.—The *abductor pollicis pedis* arises from the inner part of the larger protuberance of the calcaneum, from the internal annular ligament and the tendinous and fibrous structures on the inner border of the foot as far forwards as the internal cuneiform bone, from the septum between it and the flexor brevis digitorum, and from the plantar fascia covering it. The fleshy fibres end in a tendon, which, after uniting with the internal head of the flexor brevis pollicis, is inserted into the inner border of the base of the first phalanx of the great toe.

The *flexor brevis pollicis pedis*, single and pointed behind, but divided into

two parts or heads in front, arises by a flat tendinous process, which extends along a great part of its upper surface, from the inner border of the cuboid bone, and from the tendinous band sent to the cuneiform bones from the tendon of the tibialis posticus. The heads into which the muscular mass divides are intimately connected each with one of the sesamoid bones of the first metatarso-phalangeal articulation, and are inserted, one into the inner border of the base of the first phalanx in union with the abductor pollicis, the other into the outer border in union with the adductor.

The tendon of the flexor longus pollicis runs in the interval between the heads of the short flexor.

The *adductor pollicis pedis*, placed obliquely in the sole of the foot, and forming a thick fleshy mass, arises from the tarsal extremity of the third and fourth metatarsal bones, and from the sheath of the peroneus longus muscle ; narrowing as it passes forwards, it is inserted, conjointly with the external head of the flexor brevis pollicis, into the base of the first phalanx of the great toe.

The *transversus pedis* consists of a series of narrow fasciculi of fleshy fibres, placed transversely under cover of the flexor tendons, and arising, beneath the heads of the second, third, and fourth metatarsal bones, from the ligaments connecting those bones with the phalanges. Its outer extremity is attached usually to the lateral ligament connecting the fifth metatarsal bone with the first phalanx of the little toe ; but it often commences only at the fourth. The fibres of the muscle pass transversely inwards, and are inserted in union with the adductor pollicis into the first phalanx of the great toe.

Fig. 221.

Fig. 221.—Deeper Plantar Muscles, as seen after the removal of the Long Flexor Tendons and the Accessory and Lumbricales Muscles. ½

1, flexor brevis pollicis ; 2, adductor pollicis ; 3, transversus pedis ; 4, flexor brevis minimi digiti ; 5, 5, part of the third and fourth dorsal interossei ; 6, 6, the second and third plantar interossei ; 7, tendon of the peroneus longus passing round the cuboid bone to enter its groove ; 8, long plantar ligament passing forwards to the ridge of the cuboid bones and spreading over the groove of the peroneus tendon : in the upper part of the figure, on the inner side, the opened sheaths of the flexor longus pollicis and flexor longus digitorum are shown.

Muscles of the Little Toe.—The *abductor minimi digiti* has a wide origin behind, from the front of both tubercles on the under surface of the os calcis, from the external intermuscular septum, and from the upper surface of the process of the plantar fascia which extends from the external tubercle to the base of the fifth metatarsal bone. The fleshy fibres end in a tendon, which, after sliding along a smooth impression on the inferior surface of the base of the fifth metatarsal bone, is inserted into the external surface of the base of the first phalanx of the little toe.

This muscle is covered by the plantar fascia. Its deep surface is in contact with

the external head of the flexor accessorius, the ligamentum longum plantæ, the peroneus longus, and the flexor brevis minimi digiti.

The *flexor brevis minimi digiti* arises by tendinous fibres from the base of the fifth metatarsal bone, and from the sheath of the peroneus longus, and terminates in a tendon which is inserted into the base and external border of the first phalanx of the little toe. It is covered partly by the abductor minimi digiti, partly by the plantar fascia.

THE INTEROSSEOUS MUSCLES of the foot, like those of the hand, are seven in number, three plantar and four dorsal; the plantar interossei, visible only from the under side, arise each from only one metatarsal bone, and their action is to approximate the toes; the dorsal muscles, visible both from above and below, arise each from two metatarsal bones, and in their action separate the toes. The arrangement of the second dorsal and first plantar interosseous muscles of the foot, in relation to the toes, is somewhat different from that of the corresponding muscles of the hand.

Fig. 222.

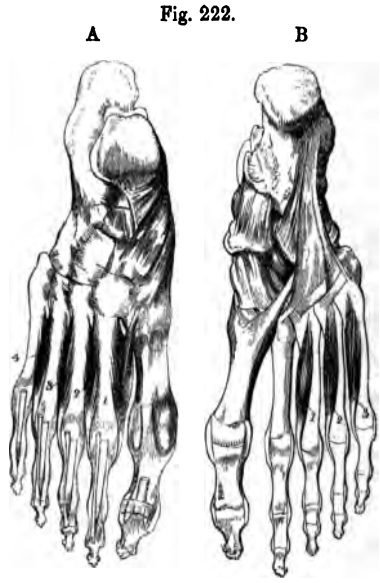


Fig. 222, A.—DEEP DISSECTION OF THE DORSUM OF THE FOOT, TO SHOW THE DORSAL INTEROSSEOUS MUSCLES. ½

1, 2, 3, 4, the several dorsal interosseous muscles: the final insertion of the extensor tendons into the phalanges of the toes is also shown in this figure, more particularly in the great toe, and the separate insertion of the tendons of the short and the long extensor.

B.—DEEP DISSECTION OF THE SOLE OF THE FOOT, TO SHOW THE PLANTAR INTEROSSEOUS MUSCLES. ½

1, 2, 3, the three plantar interossei; this figure also shows the long and short plantar ligaments, and the insertion of the tendon of the peroneus longus muscle into the first metatarsal bone.

The *dorsal* interossei are arranged so as to separate the toes from the line in which the second toe rests; they lie one in each interspace, their fibres radiating pennately from a central tendon; and they terminate partly in the first phalanx and partly in the extensor aponeurosis of the toe to which each belongs. The first two are inserted one on each side of the second toe; the third and fourth are inserted on the outer sides of the third and fourth toes.

The *plantar* interossei, arranged so as to approximate the three outer toes to the second, arise from the inner and under surfaces of the third, fourth, and fifth metatarsal bones, and are inserted in a manner similar to the dorsal interossei into the inner sides of the first phalanges of the third, fourth, and fifth toes.

ACTIONS OF THE MUSCLES OF THE LEG AND FOOT.—There is only one muscle of the leg, viz., the *popliteus*, which acts on the knee-joint alone. Its principal action is that of a rotator inwards of the lower leg; and it is interesting to observe that while rotation of the leg at the knee-joint occurs only in flexion, it is in that position only that the tendon of the popliteus lies in its groove on the femur.

The *gastrocnemius* muscle acts both as a flexor of the knee and as an extensor of the foot. When the anterior muscles of the leg fix the ankle-joint, it is fitted to act as a flexor of the knee; when the knee is fixed either by being placed in complete extension or by the sustained action of the extensor muscles, the gastrocnemius acts entirely on the foot, and combines with the *soleus* in extending the ankle and astragalo-calcaneal joints. By the complete contraction of these muscles the heel is lifted from the ground and the body is raised on the toes. In leaping, as the limb is suddenly straightened by extension both at the knee and ankle joints, the gastrocnemius acts in the most advantageous manner possible on the foot, seeing that by the movement of the knee its fibres are kept stretched.

The *tibialis anticus* muscle flexes the foot upon the leg and raises its inner side: the *peroneus tertius* flexes the foot and raises its outer side: the *tibialis posticus* extends the foot and gives it an inward direction: the *peroneus longus* and *brevis* extend the foot and give it an outward direction. The peroneus longus, in crossing the foot inferiorly, strengthens the transverse arch formed by the metatarsal bones and anterior range of tarsal bones; especially when that arch is pressed upon by the weight of the body falling on the balls of the toes, as in stooping with bended knees.

The *flexor* and *extensor muscles* of the toes, including the *lumbricales*, act like the corresponding muscles in the hand. The direction of the flexor longus digitorum is, however, modified by the *flexor accessorius*, so as to bring its line of action into the direction of the middle of the foot and of the short flexor. The flexor accessorius and tendon of the foot and of the long flexor likewise assist the short flexor and the plantar aponeurosis in maintaining the arch of the foot.

FASCIÆ OF THE LOWER LIMB.

The *superficial fascia* of the lower limb is similar to that of other parts of the body. The subcutaneous layer is continuous with that of the lower part of the abdomen. The disposition of the deeper and more membranous part on the front of the thigh deserves attention in respect that it is so firmly attached to Poupart's ligament as to prevent the passage of fluids under it, from the thigh to the abdomen.

The *aponeurosis of the lower limb*, or *fascia lata*, is similar to the aponeurosis of the upper limb, but in some parts much stronger.

In the *gluteal* region it is attached to the crest of the ilium, and descends as a strong membrane on the surface of the gluteus medius, as far as the upper margin of the gluteus maximus muscle; it there divides into two layers, one superficial to the gluteus maximus, a continuous sheet, attached at its inner end to the sacrum, the other on the deep surface of that muscle. These two layers incase the muscle, and again unite at its inferior margin.

On the *thigh* the fascia lata forms a continuous sheath, varying in thickness in different parts. It is strongest on the outer aspect of the limb, where its dense and glistening parallel fibres give it much the appearance of a tendinous aponeurosis, and where it serves the purpose of a tendon to the tensor vaginæ femoris, and to a large part of the gluteus maximus. It is thinnest in the upper and inner part of the thigh, where it covers the adductor muscles. Near the knee, it is considerably strengthened by tendinous expansions given off from the lower termination of the extensor and flexor muscles of the knee-joint.

In front of the thigh, a little below and external to the inner end of Poupart's ligament, is placed the *saphenous opening*, an aperture in the fascia lata through which the internal saphenous vein passes to join the femoral vein, and which receives special attention from its being the place of exit of femoral hernia. The outer part of this opening extends to the femoral artery, and is bounded externally by a crescentic margin, the *fal-*

ciform process, which crosses the surface of the infundibuliform sheath of the femoral vessels. This margin in the middle of its extent is continued into looser tissue, but superiorly and inferiorly it ends in two more distinct incurved extremities, the *superior* and *inferior cornua*. The inferior cornu, the most completely defined part of the margin, lies in the angle between the internal saphenous and the femoral vein, below their junction; while the superior cornu forms a larger curve, and is bound down to the fascia of the thigh a little below and in front of Gimbernat's ligament.

It is customary to call the parts of the fascia lata which are placed external and internal to the saphenous opening the *iliac* and *pubic portions*. The iliac portion is intimately connected above with Poupart's ligament, as well as with the fascia transversalis and deep layer of the superficial fascia of the abdomen, and internally forms the falciform margin of the saphenous opening; the pubic portion, attached superiorly to the pectineal line, passes on its outer side deeply behind the sheath of the vessels, with which it is connected, and is continued into the fasciæ between the muscles.

In the natural state, the saphenous opening is filled up by the *cribriform fascia*, a thin and somewhat irregular membrane which is continuous externally with the falciform margin of the opening, and is attached internally to the surface of the pubic portion of the fascia lata: it receives its name from being perforated by numerous small blood-vessels and by the superficial lymphatics of the thigh as they pass in to join the deep group.

The fascia lata of the thigh has various deep processes. One of these, leaving the main fascia at the insertion of the tensor vaginæ femoris muscle, passes upwards within that muscle as a strong flat band on the surface of the vastus externus, and is attached superiorly round the origin of the rectus femoris, and to the tendinous arch at the insertion of the gluteus minimus muscle. Two processes, the *external* and *internal intermuscular septa*, bind the fascia to the femur in the lower part of the thigh: the external septum, situated between the vastus externus muscle and the short head of the biceps, is inserted into the linea aspera from the lower border of the tendon of the gluteus maximus to the outer condyle of the bone: the internal septum, much thinner, is inserted into the femur between the vastus internus and the adductor muscles.

Sheaths of the Femoral Vessels.—The femoral vessels are surrounded by an investment of fascia, which in its upper part is particularly distinct, and receives the name of the *crural sheath*. This sheath, commencing at the deep crural arch, is continuous with the fascia transversalis and fascia iliaca. Its outer border descends in contact with the artery, while its inner border is inclined outwards from the margin of Gimbernat's ligament, and comes in contact with the vein at the distance of less than an inch lower down: the sheath is therefore funnel-shaped. It is divided into three compartments, separated by thin septa: the outermost contains the artery, the middle one the vein, and the innermost forms a space the upper end of which corresponds to the crural ring, and which is occupied by a lymphatic gland and some fat; this compartment is interesting to the surgeon as being the passage by which femoral hernia descends, and on this account has been named the *crural canal*.

Extending upwards from the opening for the femoral vessels in the adductor magnus muscle, is an aponeurotic membrane which consists of transverse fibres passing from the surface of the vastus internus to the adductor magnus and adductor longus muscles. It becomes thinner as it ascends, and it encloses between the muscles named a passage sometimes called

Hunter's canal, which contains the femoral artery and vein, together with the internal saphenous nerve.

The *aponeurosis of the leg* is particularly dense in the upper and fore part, and is strengthened by fibres from the tendons of the biceps externally, and the sartorius, gracilis, and semimembranosus internally. Behind, over the popliteal space, it consists of strong transverse fibres, which bind together the muscles of the outer and inner sides, and is perforated at the lower part of the space by the external saphenous vein; lower down it becomes much thinner over the gastrocnemius muscle. This fascia is adherent to the periosteum covering the head, the spine and the posterior margin of the tibia, the head of the fibula, and the outer and inner malleoli; and it invests the leg completely except at the inner surface of the tibia. From its deep surface intermuscular septa are prolonged inwards. The situation of these septa is marked on the surface of the fascia by several white lines in front and on the outer side of the leg. One, parallel to the spine of the tibia, runs between the tibialis anticus and the extensor longus digitorum, and is attached deeply to the interosseous membrane; and another extending

Fig. 223.

Fig. 223.—Superficial Muscles and Tendons on the Dorsum of the Foot and Lower Part of the Leg anteriorly (after Bourgery). $\frac{1}{3}$

a, lower part of the tibia; *b*, lower part of the fibula above the malleolus externus; *c*, inner side of the scaphoid bone; *d*, internal cuneiform bone; 1, lower part of the tibialis anticus muscle; 1′, its tendon descending in the groove of the internal cuneiform bone; 2, extensor longus pollicis; 2′, its expansion on the dorsum of the great toe; 3, extensor communis digitorum dividing into its four tendons for the toes; 3′, the expansion, and 3″, the final insertion of the same upon the second toe; 4, peroneus tertius; 4′, its expanded insertion on the base of the fifth metatarsal bone; 5, small part of the fibres of the soleus on the inner side of the tibia; 6, small part of the peroneus brevis; 7, extensor brevis digitorum, seen below the tendons of the extensor longus and peroneus tertius; 7′, 7″, on a band of aponeurosis crossing the toes, the first and fourth tendons of the extensor brevis muscle passing to join those of the long extensor; 8, 9, anterior annular ligament, chiefly in its lower part or ligamentum cruciatum; between 8 and *c*, the inner and lower band enclosing the extensor longus pollicis and tibialis anticus; below 9, the outer part of the same enclosing the tendons of the extensor communis and peroneus tertius; 10, 11, dorsal transverse band of the aponeurosis of the foot, uniting the heads of the metatarsal bones.

between the long extensor and peroneus tertius in front, and the peroneus longus and brevis behind, is inserted along the anterior margin of the shaft of the fibula. These septa, as well as the upper and anterior portion of the fascia itself, afford attachment to the muscular fibres, and thus increase greatly the extent of the surfaces from which the muscles derive their origin.

Between the superficial and the deep muscles on the back of the leg, a

layer of fascia is stretched from side to side across the limb known as the *deep fascia of the leg*. Where covered by the soleus and gastrocnemius, this fascia is weak, but it becomes stronger as it escapes from under cover of those muscles and approaches the malleoli.

Below the *ankle* the fascia of the leg becomes continuous with that of the foot. In front, and on the sides of that joint, it is strengthened by broad bands of fibres, which are called annular ligaments. These bands being merely stronger portions of the ordinary fascia, it is often difficult in dissection to mark satisfactorily the exact line of their upper and lower margins. They serve as retinacula, confining the tendons in their natural positions.

The *anterior annular ligament* includes two structures, one placed on the lower part of the leg, the other opposite the bend of the ankle. The *upper band, ligamentum transversum cruris* (Henle), of considerable breadth, stretches from the lower end of the fibula to the lower end of the tibia, and binds down the vertical portion of the extensor tendons as they turn forwards to the foot: the sheath for the tendon of the tibialis anticus is distinct from the others. The *lower band, ligamentum cruciatum cruris* (Henle), presents superficially the appearance of the letter Y placed upon its side, being single in its outer half, and usually divided into two branches internally. The outer portion consists of a strong loop of fibres arising from the fore part of the os calcis, completely surrounding the peroneus tertius and extensor longus digitorum muscles, and inserted into the fore part of the os calcis, deep in the hollow between that bone and the astragalus. Less regular is the arrangement of the bands which pass from the extremity of the loop to the inside of the foot: the strongest and most constant band passes superficial to the extensor pollicis and on the deep surface of the tibialis anticus muscle, only a few fibres passing superficial to the latter; while another band, lower down, is inserted into the inner side of the foot, in front of the ankle, after crossing both those tendons.

The loop formed by the outer part of this ligament derives additional interest from being present in the lower animals, as may be well seen in the dog or cat, and in the horse.

The *internal annular ligament* crosses the space between the inner ankle and the heel, through which the tendons of the flexor muscles run. Its upper border, continuous with the fascia of the leg (more especially the deep layer), is very imperfectly defined; and its lower border, giving origin to many fibres of the abductor pollicis, is but little more distinct. Its anterior extremity is attached to the inner malleolus, and its posterior termination is inserted into the inner margin of the calcaneum; but between these two points it arches over several osseous grooves so as to form canals for the passage of tendons. The first canal (next the malleolus) contains the tendon of the tibialis posticus, and the second that of the flexor longus digitorum, each being provided with a synovial lining. Then follows a wider space for the passage of the posterior tibial vessels and nerve. Lastly, a fourth canal upon the astragalus, lined like the two first by a synovial bursa, transmits the tendon of the flexor longus pollicis.

The *external annular ligament* extends from the point of the outer malleolus to the outer surface of the calcaneum, and keeps in place the tendons of the long and short peronei muscles. The tendons are close together, and are surrounded by one synovial sac.

The *fascia on the dorsum of the foot* is reduced to a thin membrane prolonged from the anterior annular ligament over the extensor tendons. Beneath it, deep fasciæ are placed over the short extensor of the toes and the interossei muscles.

The *plantar fascia* is stronger and thicker than any other of the fibrous membranes. It is composed of dense, white, glistening fibres, the greater number of which are ranged in a longitudinal direction, and extend from the under surface of the os calcis forwards to the heads of the metatarsal bones. It presents a central and two lateral portions, clearly marked off from each other by two strong intermuscular septa, indicated on the surface by grooves. The *inner* portion, very thin and unlike the others, invests the abductor pollicis, and is often partly removed with the skin in dissection. It is continuous round the inner border of the foot with the dorsal fascia and with the internal annular ligament. The *outer* part covers the abductor minimi digiti, and is much stronger, particularly between the outer tubercle of the calcaneum and the base of the fifth metatarsal bone, between which points it forms a strong ligament. It is continuous round the outer border of the foot with the dorsal fascia, and sends a thin prolongation forwards over the insertion of the abductor and the short flexor of the little toe. The *central portion*, like the corresponding part of the palmar fascia, is narrow behind, and becomes wider and thinner towards the toes. At the back, where it is thickest, the fascia is attached to the inner tubercle on the under surface of the calcaneum immediately behind the origin of the flexor brevis digitorum, with which muscle it is closely connected. Nearly opposite the middle of the metatarsal bones, this fascia, becoming broader and thinner as it advances, begins to divide into five processes, one for each of the toes ; and from this point forwards to the base of the toes, numerous strong transverse fibres are superadded, which bind the processes together, and connect them closely with the skin. Near the articulation of the toes with the metatarsal bones, each of the five processes divides, to permit the passage of the flexor tendons ; and the two bundles of fibres resulting from the division of each process, after strengthening the sheath of the tendons over which they pass, are attached to the sides of the metatarsal bone, and are blended with the transverse ligament uniting those bones. From the point of splitting of each process, as in the hand, fibrous bands are continued forwards to the skin in the division between the toes.

The two *intermuscular septa* which lie between the middle and lateral portions of the plantar fascia are prolonged deeply upwards into the sole of the foot ; they separate the flexor brevis digitorum from the abductor pollicis on the inner side, and from the abductor minimi digiti on the outer side, and give partial origin to each of these muscles.

In both the foot and the hand there is a band of transverse fibres across the roots of the digits, placed immediately beneath the skin, and connected with the subjacent sheaths of the tendons. The digital nerves and vessels are covered by this structure, which receives the name of *transverse ligament* of the toes or fingers. In the foot a somewhat similar band, but consisting merely of a stronger part of the dorsal aponeurosis, crosses the place of the metatarso-phalangeal articulations.

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